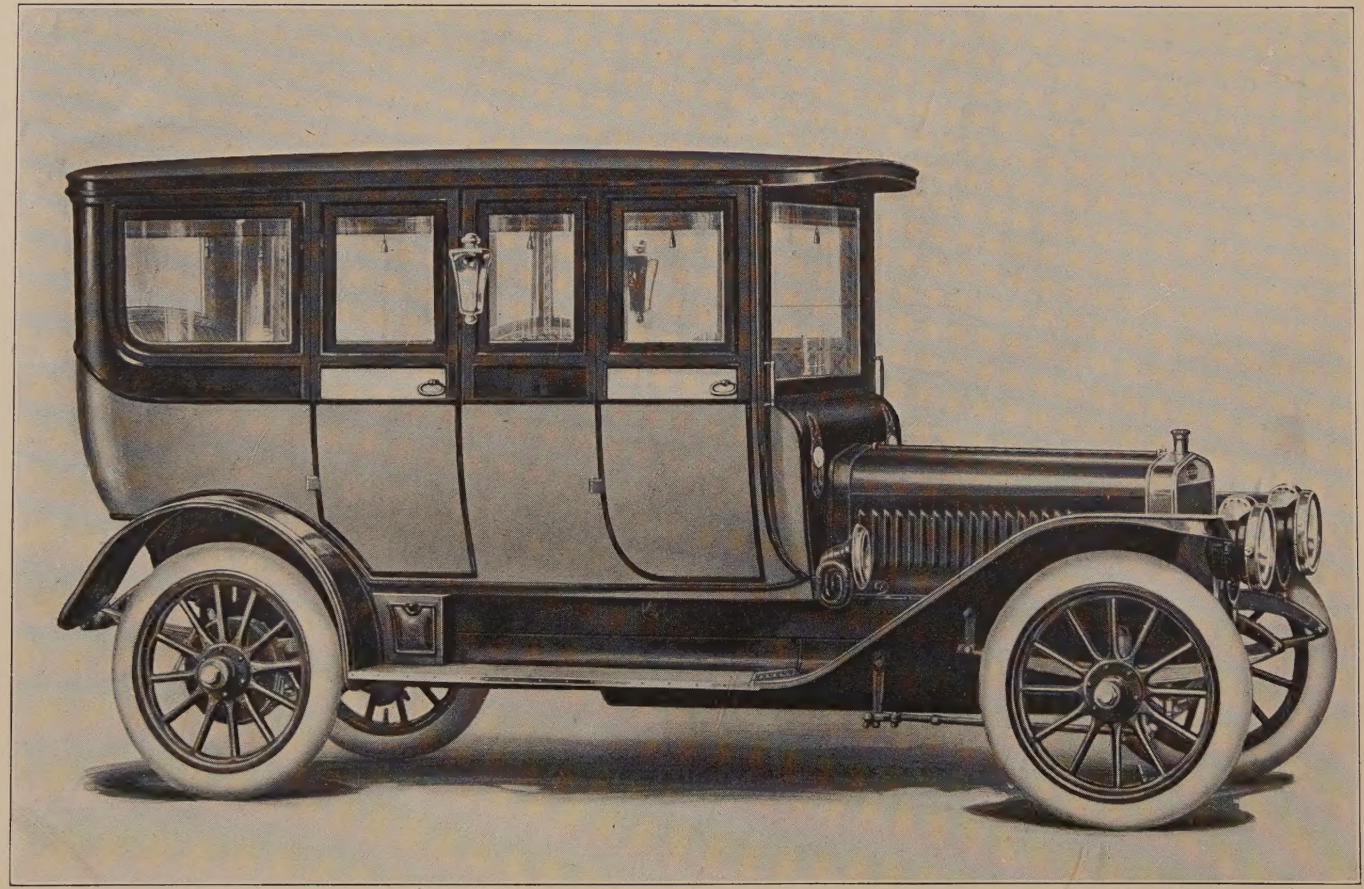

WINTON SIX FOUR-DOOR LIMOUSINE

The Winton Motor Car Company, Cleveland, Ohio

Cyclopedia
of
Automobile Engineering

A General Reference Work on

THE CONSTRUCTION, OPERATION, AND CARE OF GASOLINE, ELECTRIC, AND STEAM AUTOMOBILES, COMMERCIAL VEHICLES, MOTORCYCLES, AND MOTOR BOATS; TYPES OF AUTOMOBILES; EXPLOSION MOTORS; DRIVING; GARAGES; REPAIRS; AERONAUTICS

Prepared by a Staff of

AUTOMOBILE EXPERTS, CONSULTING ENGINEERS, AND DESIGNERS OF THE HIGHEST PROFESSIONAL STANDING

Illustrated with over One Thousand Engravings

FOUR VOLUMES

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1912

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Grateful acknowledgment is here made also for the invaluable co-operation of the foremost Automobile Firms and Manufacturers in making these volumes thoroughly representative of the very latest and best practice in the design, construction, and operation of Automobiles, Motorcycles, etc.; also for the valuable drawings, data, illustrations, suggestions, criticisms, and other courtesies.

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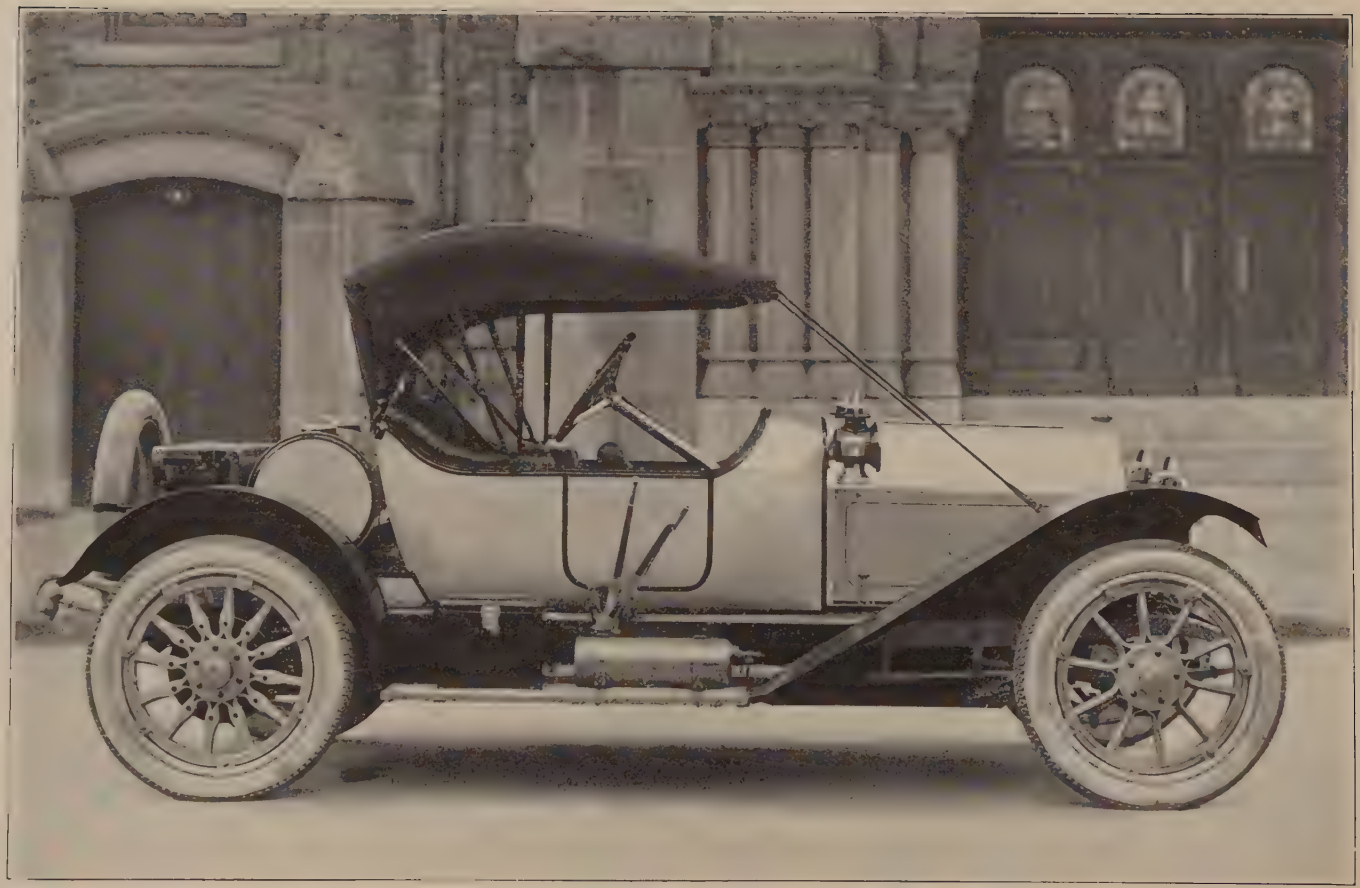
Premier Motor Manufacturing Company, Indianapolis, Indiana



STUTZ ROADSTER

The Ideal Motor Car Company, Indianapolis, Indiana

Foreword

WITHIN recent years the internal-combustion motor and the self-propelled vehicle have become such important factors in the evolution of industrial, commercial, and social life, that a distinct need has been created for an authoritative work of reference embodying the results and methods of the latest approved practice in the construction, care, and operation of the various types of motor cars and other vehicles driven by gas, steam, and electricity, and in allied branches of this rapidly developing field of apparently unlimited possibilities. It is the purpose of the Cyclopedia of Automobile Engineering to fill this acknowledged need.

¶ The application of the internal-combustion motor, the steam generator, the storage battery and electric motor, to the development of types of mechanically propelled road carriages and motor boats, is a far-reaching engineering problem of great difficulty. The same is true of the airship motor and the application of the gas engine to the development of efficient and economical methods of power production for aërial navigation. While not all details of these problems have as yet been finally worked out or reduced to standard practice, sufficient progress has been made to assure results of permanent value. In so far as these results are embodied in the constructions used in typical modern cars, they are presented in these pages without any attempt at great refinement of engineering subtleties,

but with all explanation of details essential to a working knowledge.

¶ Special stress is laid on the practical as distinguished from the merely theoretical or descriptive form of treatment, so that these volumes will be found especially adapted for purposes of self-instruction. They are designed not only to meet the requirements of instruction for the novice, but also to serve as a reference work replete with information and suggestions of the utmost practical value to the most experienced chauffeur and engineer.

¶ The method adopted in the preparation of the Cyclopedia of Automobile Engineering is that which the American School of Correspondence has developed and employed so successfully for many years. It is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best method yet devised for the education of the busy man.

¶ For purposes of ready reference and timely information so frequently needed in automobile operation and construction, it is believed that these volumes will be found to meet every requirement.

¶ Grateful acknowledgment is due the corps of authors and collaborators—engineers of wide practical experience, and teachers of well-recognized ability—without whose co-operation this work would have been impossible.

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KNOX PAY-AS-YOU-ENTER BUS TWENTY-EIGHT PASSENGER CAPACITY

Knox Automobite Company, Springfield, Massachusetts

COMMERCIAL VEHICLES

PART I

INTRODUCTION

Much wonderment is frequently expressed at the comparatively slow development of the motor-driven vehicle for commercial usage in this country, and this is increased when it becomes known that the actual advent of the business automobile took place not very long after that of its rival—the pleasure car—which has since monopolized the center of the stage. But the underlying reasons are neither numerous nor complex. Reliability is naturally the chief essential in commercial service and this was possessed in no great degree by the early models of the present day commercial vehicles —probaby less so than was the case with the pleasure car. Huge sums of money are tied up in horse-drawn equipment and the average business man naturally hesitates to change—in fact, it is but a repetition of the history of the horse and the trolley car. It is only a question of a few years when the power wagon will have displaced its predecessor quite as generally as has electric traction the horse car in street-railway service.

It is important to know the reasons for the revolution that is now in active progress, as well as to become familiar with the prevailing practice in America and abroad, in the construction, operation, and maintenance of that large and varied class of automobiles which is employed exclusively for business purposes. Regardless of type, class, or method of propulsion these are commonly referred to as *commercial vehicles*. This classification embraces not alone motor delivery wagons and trucks for the transportation of merchandise, but likewise taxicabs, omnibuses, sight-seeing vehicles, motor road trains, farm tractors, emergency repair or tower wagons for street-railway service, and also special municipal service vehicles—ambulances, patrol wagons, fire engines, street sprinkling and garbage removal wagons and the like. In fact, it may be said that any auto-

mobile not devoted to pleasure is a commercial vehicle, and as was naturally expected, the first commercial vehicles were merely pleasure cars transformed to suit the needs of the occasion. To a certain extent, this still continues to be the case.

Standard Design. Whether it be electric-, steam-, or gasoline-driven, the general design of the motive power as well as that of its transmission to the driving wheels is practically the same in the commercial vehicle as it is in the pleasure car. All of the component parts of the latter—bearings, frames, axles, steering gear, and compensating mechanism—have their counterparts in every industrial vehicle. In other words, the chassis in either case is composed of similar members. For the sake of brevity in the present treatise, it is assumed at the start that the reader has become familiar with motor-car engineering in so far as it relates to pleasure-car construction; that he understands from previous study and actual handling of machines, the theory of the operation of the internal combustion engine; that he is conversant with the distinguishing characteristics of the several types of engines as well as their advantages and limitations; and that he is acquainted with the types of transmission systems ordinarily employed on pleasure cars—in brief, that he understands any reference to component parts, their functions and their relation to one another, without the necessity of explanation.

In common with the pleasure car, the commercial vehicle is capable of traveling at various speeds wherever road conditions will permit it to go. Both comprise in a single entity, a wheeled vehicle suitable for transportation purposes, fitted with an independent, self-contained power-plant. To this extent, they both present the same engineering problems in so far as they relate to the construction of the motor, its control, and the transmission of its power to the road wheels, the design of the running gear, and the control of the vehicle itself. Divergence in practice is encountered with the consideration of the purposes for which each vehicle is designed. The pleasure car is not intended to be a particularly efficient vehicle. Its carrying capacity bears but a comparatively insignificant ratio to its total weight, and the car is not usually designed to work under the same severe and continued conditions of service which are the first requirement of the commercial vehicle. It must

be capable of high speed with its maximum load of passengers and must combine reliability with endurance to a sufficient extent to meet the demands of its owner on pleasure bent. A little consideration of these factors may throw some light on the difficulty which was encountered in previous years in convincing the enthusiastic motorist that automobiles would be a *paying investment* in his business.

Requirements in Commercial Field. Reliability is naturally the prime essential in the business vehicle; then come efficiency, economy, and endurance. The combination of these three qualities make it so superior to horse traction as to admit of no comparison in the results obtainable. The accomplishment of the first-named has naturally been the outcome of years of experience in the development of the pleasure car and the application to the commercial vehicle, of the lessons thus learned. Until this was achieved, it was naturally difficult for the motor vehicle to compete with its time-tried, though slow and inefficient, predecessor. Efficiency means the maximum weight of the useful load transported, in proportion to the weight of the vehicle itself; this element also involves economy, as the vehicle and its load must be moved at a speed greater than is possible with horses. To meet these difficult requirements, it is necessary, first, to provide a self-propelled vehicle in which the nicest possible proportion of vehicle weight to maximum useful load capacity is realized; second, to employ a motor of sufficient power and suitable speed reduction through its transmission to the road wheels that will enable the machine to ascend the steepest grades with full load, and yet not overburden the machine with superfluous weight or power for safe and reasonable speeds on the level; and third, to proportion every part so as to insure the longest life to the vehicle and the greatest economy in its use. It is not the province of the present treatise to discuss these problems and their solution from the engineer's viewpoint, but to consider the machines as they are at present built in this country for the benefit of the user. This term is intended to apply to the driver and the traffic department head, quite as much as the merchant who looks upon the adoption of the power wagon solely in the light of an investment.

The keynote to the successful commercial vehicle is reliability and economy in operation. It must compete with all other forms of transportation—carrying merchandise or passengers quicker and

cheaper per ton mile or per passenger mile than the horse-drawn vehicle, and either cheaper or quicker, or with greater convenience in many cases than the railroads, this phase of the problem naturally only involving short hauls. When it is borne in mind how easily anything in the form of a pleasure automobile has been marketed during the past five to eight years, it will be apparent why manufacturers generally were loth to attempt the solution of the commercial vehicle problem. To put it bluntly, "There was no money in it," and the task was a thankless one. Not that the possibilities were unthought of. The pioneer automobile builders realized the great promise of the future for the motor delivery wagon, truck, and bus, quite as fully at the outset, as their confrères do today. In fact, in this country the first general use of the electric vehicle—the cab—was for purely commercial purposes. Not a few electric and steam vehicles were built for business purposes during the period from 1897 to 1902—a time which the modern motorist regards as the dark ages. There were also a small number of gasoline-driven commercial cars constructed during the period in question, and some of them have been rendering service steadily ever since. It is needless to add that they represent a bright exception, as the internal-combustion engine for vehicle use was then in the primary stages of its development and the patience required to perfect it called for more persistent effort than many were capable of.

Imperfect Service Brings Reaction. As is inevitable when anything is placed on the market in a crude state, a reaction will follow its adoption as soon as its shortcomings make themselves apparent. Inventors and manufacturers naturally could not afford to perfect the commercial machine at their own expense. As was the case with the pleasure vehicle, the buyer had to bear the burden of experimental expense. Early commercial vehicles, as a consequence, fell shorter of materializing their purchasers' expectations than did the pleasure cars, for the former were intended to show a definite return on the credit side of the balance sheet, while in the latter case, expense was only a thing to be reckoned with when it exceeded the purse of the car's owner. Over-light construction was the chief structural defect of the first steam vehicles in this country, while it did not take long to demonstrate that steam, in the manner then employed, was not the long-sought power for commercial use. As a

result, the fire-tube boiler type of steam car disappeared almost completely. Excessive weight in proportion to load capacity, marked inefficiency and excessive depreciation of the batteries, these were some of the discouraging features encountered in the attempt to electricity through the medium of the storage battery. The almost utilize entire absence of the factor of reliability in service settled the score of the gasoline-driven machine. Add to the above the fact that repairs and replacements were an unduly large proportion of the expense in every case, and that the vehicles were frequently out of service, and it will be easy to understand why merchants generally did not enthuse over the commercial motor vehicle.

Reliable Gasoline Car Solves Difficulty. It was really not until the gasoline-driven pleasure car had arrived at a point where it could be depended upon to give satisfaction in the hands of the ordinary driver, that interest in its commercial possibilities reawakened. Attempts to utilize the electric vehicle had been continued in the interim, and, in the aggregate, quite a number of these machines were turned out, many of them still being in active service. But the number of manufacturers devoting attention to this branch was very small, and it has only been in comparatively recent years that any decided progress has been made. Strange as it may seem, successful builders of gasoline pleasure cars have not been responsible, as a whole, for the development of the commercial vehicle. When attention was again turned to this field after the period of inaction, a new group of manufacturers came into existence. Then, with the lessening need of experimental work on the pleasure car, builders of the latter again took up the commercial side seriously, so that it is safe to say that today, there is scarcely an automobile manufacturer in the country that is not either actually producing commercial vehicles or contemplates doing so in the immediate future.

Generally speaking, this second stage in the development of the motor-driven industrial vehicle, which is now in full swing, had its inception about 1905. Since then, the number of manufacturers devoting attention to the gasoline type has increased so rapidly that the makers of electric and steam cars combined, form but an insignificant fraction of the total. In fact, there is but one American manufacturer doing any considerable business in steam-powered

commercial vehicles. In England, the latter have met with considerable success, particularly for heavy haulage purposes, but there has been little attempt made to introduce them here and the few that have actually been tried have been unsuccessful. Electric vehicles still hold their own and are being produced in larger numbers than ever, but there has been no increase in the number of makers turning them out. There are now possibly a dozen, all told, building electric delivery wagons and trucks, and the prospect of any further increase in this direction appears remote. As compared with this showing of the present output of the two types that originally monopolized the commercial field to a very large extent, there are now half a hundred or more well-established manufacturers of gasoline commercial vehicles and additions to the ranks are frequent.

Classification. In order to make the subject as clear as possible, and facilitate reference on the part of the reader, industrial motor vehicles as a whole have been classified, first, by their motive power, and second, by the uses for which they are intended. Thus there are, in the order of their relative importance today:

Motive Power	Gasoline-driven vehicles Electric vehicles Gas-electric vehicles Steam vehicles
Types of Vehicles	Delivery wagons Trucks, vans, and similar freight carriers Passenger vehicles—stages, buses, taxicabs, sightseeing cars, etc. Municipal vehicles—patrol wagons, ambulances, fire apparatus, garbage removal wagons, street sprinklers, etc. Special types—railway tower wagons, emergency repair wagons, vacuum cleaning outfits, farm tractors, road trains, etc.

This classification has been made advisedly, for though kerosene and alcohol are being experimented with as fuels for the internal combustion engine, and particularly for commercial purposes, by far the great majority of types marketed at present are driven by gasoline fuel.

Each of the foregoing principal divisions is susceptible of further subdivision, but this is neither necessary nor desirable. Commer-

cial motor vehicles are now built for almost every conceivable purpose involving the haulage of freight or the transportation of passengers, including many special uses, such as hauling huge reels of telephone cable and drawing the cable through the underground conduits, transporting safes and pianos and hoisting them, delivering coal with special dumping wagons, and the like. They differ only in the special equipment with which they are provided for the service in view and as their construction otherwise is the same, it would only lead to confusion to attempt to consider them separately.

ELECTRIC VEHICLES

Though no longer a predominant feature of the commercial vehicle situation in this country, as the electric machine was the first type to score any considerable success in the commercial field, it is appropriate that it should be taken up first. It has been freely predicted in the past that the electric vehicle would disappear entirely with the development of the gasoline-driven machine, and there are still those who are of the same opinion today. In view of the startling evolution of the automobile industry as a whole in the past few years, it would be folly to attempt to predict what the ensuing decade may bring forth, but it seems safe to say that the electric will continue to fill the rôle in which it has proven so successful, for some time to come. It has a field all its own, and, up to the present, other types have not been able to invade the field to any extent, this being quite as true of the pleasure car as of its commercial confrère.

Advantages. One of its chief advantages from the purely commercial point of view, is its great simplicity, which to a very large extent solves the labor question that has proved such a deterrent to the adoption of the gasoline vehicle for commercial service. As the duties of the driver of an electric vehicle do not extend beyond its actual starting, stopping, and guidance while under way, anyone who has been accustomed to the use of horses can master its operation in the course of a few hours. This also appears to be equally true of men who have never driven any type of vehicle previous to their taking the wheel or steering tiller of an electric. Apart from the actual mechanical control of the vehicle, the driver's only other care is to keep informed as to the state of charge of the battery by watching the voltmeter, in order to prevent running the car with the batteries

in an exhausted condition, as this is very detrimental to their continued usefulness. However, as most commercial vehicle batteries are charged every twenty-four hours and the car's run is planned to lie within its traveling radius on a single charge, with a factor of safety allowed in addition, this is not a very onerous duty. The further requirement of noting the current consumption on starting and running, as indicated by the ammeter, in order that any defect in the operation of the running gear of the car may be detected and remedied, is also a very simple one, so that an unskilled driver is available at a correspondingly lower charge for labor cost in the operation of the vehicle.

Power Efficiency. The amount of power available on a single charge of the batteries without unduly increasing the weight is so limited, that in the design of the electric great care must be taken to eliminate friction and other sources of power loss at every possible point. This is further necessitated by the gradually decreasing efficiency of the batteries with age. Starting at 80 per cent efficiency when new, this may rapidly drop to 50 per cent or below, unless the batteries are properly maintained, and this is likewise true of the transmission efficiency of the running gear of the vehicle, so that while unskilled labor may be employed for the operation of the vehicles, this is not the case where their maintenance is concerned. Power losses due to the tires are also an important factor, and as the pneumatic can very seldom be considered for commercial service, the same degree of efficiency is not obtainable from the business electric wagon as from the pleasure type employing the same motive power. Road conditions must also be considered, despite the fact that electrics are employed almost exclusively for city or near by suburban service, as mud, snow, and ice in winter, and poor pavements at any time, cause an increase in the current consumption.

It is safe to say that if improvements in design had not been effected as the result of experience, the electric vehicle would now have been practically eliminated as a factor of importance in the commercial vehicle situation, as the early types were extremely wasteful of power. One of the many reasons for this was the employment of two motors, which were at first considered necessary. It was found that the substitution of a single unit of slightly less capacity than the combined power of the pair previously employed was a

long step in advance where power saving was concerned, and the practice of using but one motor even on comparatively heavy vehicles is now generally followed. This also served to cut down transmission losses, though it involved the use of a balance gear, or differential, to take the place of the independent drive to each rear wheel that was in vogue when two motors were used. The abandonment of a spur-gear drive in favor of chains was also a further improvement in the same direction. This made possible the removal of the motor from proximity with the driving wheels, to a point on the chassis where its weight could be better supported by the springs, thus effecting a step in advance on the score of maintenance as the motive power was no longer subjected to the severe pounding.

ELECTRIC DELIVERY WAGON

Whether considered from the point of view of design and construction, or from that of operation, the electric delivery wagon is without doubt the simplest vehicle in the commercial field. As already mentioned, its operation may be mastered in a comparatively short time, either by the ex-horse driver, or by a person who has never had any experience in the control of a vehicle, so that the labor cost—always an item of importance in this field—may be materially reduced without fear of the equipment suffering in consequence. It will be noted under on "Electric Trucks," Page 22, that it is customary with manufacturers of these vehicles to adopt a standard form of design, which is employed throughout in every size listed by the same maker, the only differences being those of dimension, load capacity of the vehicle, and capacity of the battery to take care of the increased weight.

This is likewise the case where electric delivery wagons are concerned. For instance, all the Studebaker delivery wagons are characterized by the same feature of design, except the one rated at 500-pounds capacity which is intended for very light work. This car is equipped with a single, high-speed electric motor, placed forward under the body and arranged to drive the rear wheels through a countershaft and chains. All the others are equipped with two motors which are placed near the rear wheels and drive the latter by countershafts, roller chains, small sprockets on the ends of the armature shafts and large ones bolted to the driving wheels.

Package delivery wagons and express wagons of the electric type have a useful load capacity ranging from 500 to 2,000 pounds, though very few of less than 1,000-pounds capacity are now built or employed. They are designed for maximum speeds of 10 to 15 miles an hour under favorable conditions on the level, and are fitted with batteries permitting of a maximum traveling radius of 40 to 50 miles on a single charge. The 40-mile run is standard and is based on an average speed of 10 to 12 miles an hour, including stops, as the necessity for frequently stopping and restarting the car in delivery service has an important bearing on the mileage of which the car is capable on a single charge. The latter is naturally figured on the maximum efficiency of the car as a whole, so that in practice this is seldom fully realized, due to the deterioration of the batteries in service. Consequently, while there are numerous instances on record of vehicles doing 40 miles a day or better, 25 to 30 miles will more nearly represent an average figure.

Design. The design of many of the early electric vehicles followed very closely the lines laid down and adhered to for so many years by the wagon builder. That is, the entire vehicle was a unit. Then, the practice of making the power-plant and running-gear, or chassis, entirely independent of the body, which obtained in the gasoline field, was followed and is representative of the usual electric vehicle construction today. This permits of fitting any style of body desired by the user. As a matter of fact, as soon as engineering practice became fairly well standardized, as applied to the design of the gasoline-driven car, that of the electric vehicle followed it more or less closely, except as necessarily modified by the difference in the motive power. Thus, it will be noted that the electric has progressed through the stages represented by the angle-iron frame, armored wood frame, and modifications of the two as employed on gasoline cars, to the now generally current type of pressed steel frame. This has the advantage of being extremely strong for its weight. It is composed of side and transverse members produced in hydraulic presses directly from steel plates of about $\frac{5}{16}$-inch thickness, these members being riveted together and further reinforced by gussets at the corners. On account of the height of the vehicle, the frames are made perfectly rectangular and without either a drop or narrowing forward.

The types of suspension employed also show the same variations as are to be found in the gasoline-driven cars, some of the smaller electrics having full elliptic springs as ordinarily employed on wagons, while intermediate and heavy vehicles have either straight semi-elliptic springs front and rear, or a half-platform type of suspension in the rear. A study of the Studebaker and General Vehicle types of delivery wagons and trucks will show how closely they approach to what is considered general practice in the automobile field as a whole. The latest Lansden vehicles are distinguished by a novel form of suspension employing groups of helical springs, and represent about the only departure of note.

Where the axles are concerned, the electric still bears traces of its predecessor, the horse-drawn wagon, as these are usually straight forgings of square section, though tubular axles are employed in some of the lighter cars. The steering spindles on the front axles and the wheel spindles on both front and rear follow conventional practice, as ball or roller bearings are generally employed. Because of the heavy loads carried and the fact that solid tires are used, the entire running gear has to be planned on a very liberal scale. This is likewise true of the springs. While it is desirable that the latter afford as much protection to the mechanism as possible, sufficient stability to carry the load is of more importance than flexibility, as the comparatively slow speeds do not occasion either the rapid oscillations or the violent shocks that are met with in the pleasure car with its light load and high speed.

Motive Power. As already mentioned, the motive power of the majority of smaller electric vehicles consists of a single motor, and in some makes, such as the General Vehicle, this practice is extended into quite heavy units with a corresponding increase in the efficiency of the vehicle as a whole. In order to keep down the weight as well as the space occupied, these motors are very small for their power output and consequently have to be wound for high rotative speeds. They are usually of the series type, of General Electric or Westinghouse make, and are designed to carry heavy overloads for short periods to enable the car to pull out of a bad place, to start with full load on a heavy grade, or to meet similar emergencies, the motor, under such conditions, delivering an amount of power totally disproportionate to its size, and particularly to its normal

rating. This brings up a question that has proved very puzzling to the layman, and frequently to the engineer not familiar with electrical practice. If at least 20 to 25 horse-power are necessary for the average small gasoline car, how is it possible to run a delivery wagon with a 2½-horse-power electric motor, and a truck of no mean proportions with but 5 horse-power? The overrating of the amount of power necessary in the first case, and the undervaluation of the actual amount of power available in the second go a long way toward explaining this. Though the gasoline car is equipped with a 25-horse-power motor, it seldom uses more than 40 to 50 per cent of what is available; in fact, assuming the vehicle to be in good condition throughout, it probably does not require more than 10 to 15 horse-power to drive it on the level, at any speed up to 30 miles an hour.

The electric on the other hand, has a 2½-horse-power motor which is really a 10-horse-power motor, or 5 horse-power at least, and which may be 15 horse-power, when occasion demands it, as many of these motors are capable of overloads up to 500 per cent of their normal capacity. Furthermore, there is the extremely important factor of speed and its complement, wind resistance. Speeds are so slow in commercial vehicle practice that wind resistance is practically a negligible factor, even with the towering bodies of motor vans which present a very large area, as this influence does not make itself apparent much under speeds of 25 miles an hour. Discussions which have taken place regarding this seemingly great discrepancy in the motive-power equipment of the average electric and gasoline car, recall those regarding the same feature of the pioneer electric street cars as compared with their predecessors. Two, or three horses at most, sufficed to haul the cars up grades that some of the first power-driven cars with 15-horse-power motors could not get over. In any case, why should it take 15 horse-power to drive a car that had formerly only required a team of horses to move it? Weight and speed were naturally not taken into consideration, as the old horse car was as light as a wagon and ran much easier, though the general misconception prevailing as to just what a horse-power is and what a horse is capable of were principally responsible. Careful experiments carried out by an English engineer have proved conclusively that the average draft horse is capable of exerting the equivalent of all the way from 4 to 13 horse-power for periods as long

as five minutes at a time. Consequently, the light car with its two horses really had available several times as much power, based on the horse-power unit, as appeared to be present.

Motor Suspension. Since the employment of spur-gear drives has become less general, the motor is usually suspended from the frame by means of transverse members riveted to the side rails, and is placed near or slightly forward of the center of the chassis, in order to give the best distribution of weight. This is an advantage that is not obtainable when the motors are hung from the rear axle, or too close to it. In view of the high speed at which the motors run—1,800 to 2,000 r. p. m. or more—a reduction in two stages is necessary to avoid the employment of excessively large sprockets. The first step is from the motor to a countershaft by means of a single silent chain of the Morse or Renold type, the motor being suspended in such a manner that it may be moved a short distance one way or the other to permit of adjusting this chain to the proper tension. The large sprocket on the countershaft, which serves to cut down the speed in the proportion of about 1 to 5, also embodies a differential or compensating gear of the usual bevel or spur type, thus making it possible to employ a solid one-piece axle, instead of weakening the latter by inserting the balance gear in it. This is an important feature as the rear axle must bear 60 to 70 per cent of the total weight of both car and load. From the countershaft, chains are run to each of the driving wheels. The relative positions of the countershaft and rear axle are maintained by heavy adjustable radius rods, attached forward to the outer ends of the countershaft, and at the rear to the axle. These take the stress of the drive off the springs and counteract the tendency of the chains to draw the rear axle toward the countershaft under the pull of the motor.

Where two motors are employed, as in the Studebaker 2,000-pound wagons, they are suspended side by side from the frame by special swinging hangers with their armatures practically in line with one another. But each motor is entirely independent of the other and serves to drive one of the rear wheels to which it is directly connected by means of a roller chain, passing over a small sprocket on the armature shaft of the motor forward and a large one on the hub of the driving wheel at the rear, there being but a single step in the speed reduction in this case. As there is no mechanical connection between

the two motors, or between the two driven wheels, the latter are free to rotate at different speeds when necessary and a compensating gear is dispensed with altogether. This also gives the further advantage of not losing traction entirely when one of the driving wheels turns loosely on ice, mud or sand, as is the case with the differential, which nullifies the driving effort applied to the opposite wheel when its mate revolves freely. Chain drive as now employed is not only more efficient, but less noisy and much easier to maintain and repair than the spur-gear drive formerly in vogue, though the protection of the chains by suitable cases to keep off mud and maintain lubrication would be an improvement.

As the motors commonly employed are wound to take current at 80 to 85 volts, the battery consists of 44 cells, divided into three or four groups of cells held in separate oak boxes, or *trays* as they are termed, to facilitate handling. This voltage is standard, regardless of the size of the vehicle, the latter being compensated for by changing the capacity of the battery. Thus, for very small delivery wagons, the cells each contain three positive and four negative plates of medium size giving an 85-ampere-hour discharge capacity, while a 1,000-pound wagon is equipped with a battery having nine-plate cells with a capacity of 112 ampere hours; a 2,000-pound wagon, eleven-plate cells of larger dimensions, giving 140 ampere hours; and so on in accordance with the size of the vehicle and the load it is designed to carry. However, the weight of the battery increases so rapidly with increase in capacity that it has not been found desirable to attempt to use very large units.

In the very small delivery wagons listed some years ago, it was customary to carry the battery on the floor of the vehicle, putting a second flooring above it to accommodate the load. This practice has been abandoned for obvious reasons, as it made both the loading floor and the center of gravity of the vehicle much too high. Practically all electric vehicles at the present time have the battery underslung, *i. e.*, carried in a cradle supported from the frame of the chassis. This cradle is enclosed as a battery box for protection against mud and water, and has hinged doors at the ends through which the battery may be introduced or removed. By this arrangement the weight of the battery, which is the heaviest single item in the entire construction, is distributed evenly between the forward and rear

wheels and leaves the entire floor space of the wagon available for the load. All of the wiring between the battery, controller, and motor is carried beneath the floor and is protected from injury.

Control. The controller itself is placed either beneath the seat or under the footboards in the case of delivery wagons and light trucks, and is similar in construction to those employed on street cars, but of much smaller size due to the low voltage and comparatively small amount of current to be handled. It is operated by a small hand lever and provides three to five speeds ahead and two or three reverse, all of which are obtainable by moving the same lever, although a special lock or catch must first be operated before the vehicle can be moved backward. This usually takes the form of a pedal or kick plate which may be depressed with the heel and frequently must be held down while reversing. It automatically returns the controller to the ahead position when released, in order to prevent the vehicle from being backed inadvertently.

At first, arrangements for steering took the form adopted on the earliest gasoline cars, that is, the tiller or hand-lever form, but, owing to its numerous shortcomings, this has now disappeared on all but the lightest wagons. Left-hand control is often provided, *i. e.*, both the controlling lever and the steering wheel are placed on the left side of the wagon, which is most convenient on delivery wagons as the driver's helper may leave and enter the wagon without going round the vehicle.

Wheels. The usual artillery pattern, wood wheels are employed and are almost universally carried on ball or roller bearings. Their sizes reveal the conflict between the influence of ordinary delivery wagon design and automobile practice, as some have 36-inch front and 42-inch rear wheels—an old time horse-drawn wagon standard—while others have 32- or 34-inch wheels all round as has become customary in automobile building. The larger wheels are advantageous, however, as they run easier on poor pavements and consume slightly less power, their greater diameter being compensated for by a correspondingly greater drop in the speed reduction from the motor to the rear wheels, in order to keep the speed of the vehicle the same. By modifying the design of the axles or frame, or both, the loading platform of the wagon may be kept at the same height relative to the ground, regardless of the size of the wheels, so that the employ-

ment of larger diameters is becoming, more common. This, again, is but a reflection of the tendency of design in gasoline pleasure car construction, in which 42-inch wheels are now employed, and affords an instance of reversion to original standards, as pioneer automobiles were all of the high-wheel type.

Brakes. Owing to the comparatively low speeds, the braking equipment usually consists of but a single set of drums attached to the driving wheels. Against the inner faces of these, bronze shoes are expanded directly on the steel face of the drum by means of a pedal and the usual brake rigging beneath the car. As is the case in practically all chain-driven cars, the braking drums carry the driving sprockets on their outer faces. In case of emergency, the vehicle may be brought to a sudden stop by reversing the motor, although this subjects the motor as well as the entire vehicle to unusually severe stresses.

Tires. While solid rubber tires are most generally employed, this is not necessarily so, as where the merchandise to be carried is of a light or fragile nature, or where speed is to be one of the chief features of the delivery service, pneumatic tires are preferable. They not only reduce the liability to breakage, but also lessen the cost of maintaining the vehicle in repair. However, as there are comparatively few branches of commercial service in which the pneumatic tire is economically practical, its use is very limited. The solid tires employed vary in size from two to four inches, and for weights in excess of the capacity of the latter, they are used in twin form on the rear wheels.

Types. Fig. 1 illustrates the Studebaker 800-pound load capacity, delivery wagon. It is equipped with a 40-cell Exide lead-plate battery, supplying current at 84 volts to two high-speed series motors which drive the rear wheels directly by chains, as already described. The vehicle has a speed of 2 miles to 12 miles per hour, and is capable of traveling 35 miles on a single charge of the battery. The battery is located almost directly under the center of the pressed steel frame, and the battery compartment is built integral with the frame itself, forming an inverted truss. The axles are heavy drop-forgings, and owing to the use of two motors, no differential is employed on the rear, the motors, battery, and all other parts of the mechanism being carried by the springs, which, in the smaller types, are of the

SAURER MOTOR BUS—CAPACITY THIRTY-FOUR PASSENGERS

International Motor Company, Allentown, Pennsylvania

elliptic type ordinarily employed in wagon-building practice. There are two sets of brakes, each working independently, and arranged to be applied by pedal levers, one set controlling expanding bands in drums on the rear wheel hubs, while the other brakes are of the same type but are mounted on the motor countershafts. Plain parallel bearings are employed with ample bearing surface. The dimensions of the 800-pound wagon are: wheel base, 84 inches; gauge, 59 inches; wheels, 36 by 2½ inches front and 42 by 2½ inches rear, the tire equipment being solid rubber, though iron or wood tires may also be had.

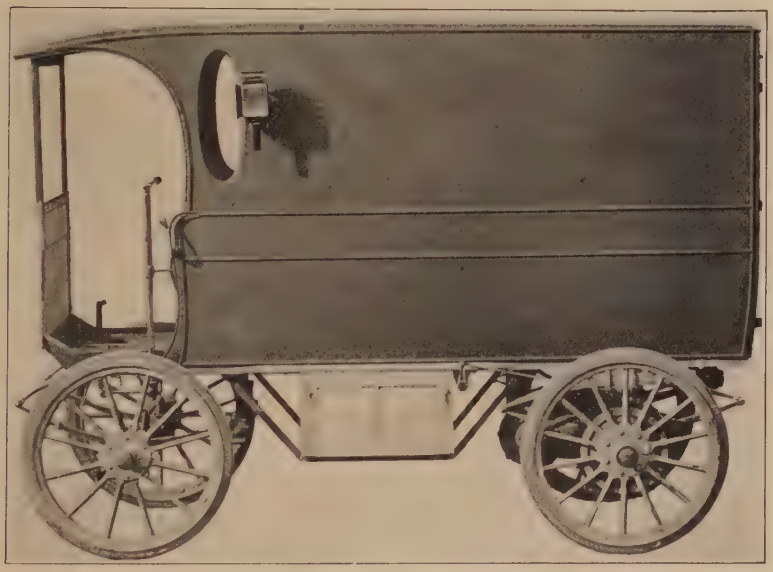


Fig. 1. Studebaker 800-Pound Electric Delivery Wagon.

In addition to the usual control, an emergency switch is provided within convenient reach of the driver, making it possible to quickly shut off the power from the motors altogether. This switch can only be moved when in a certain position; it also answers as a lock when the vehicle is standing. One of the 1,500-pound Studebaker wagons is shown in Fig. 2 with an open express type of body, and it will be noted that its design is identical with the smaller vehicle already described.

The Waverley electric delivery wagons are characterized by the employment of a single motor, as is also the case with the majority

of others in this field. This drives to a countershaft, from which the final drive is taken to the rear wheels by the usual roller chains

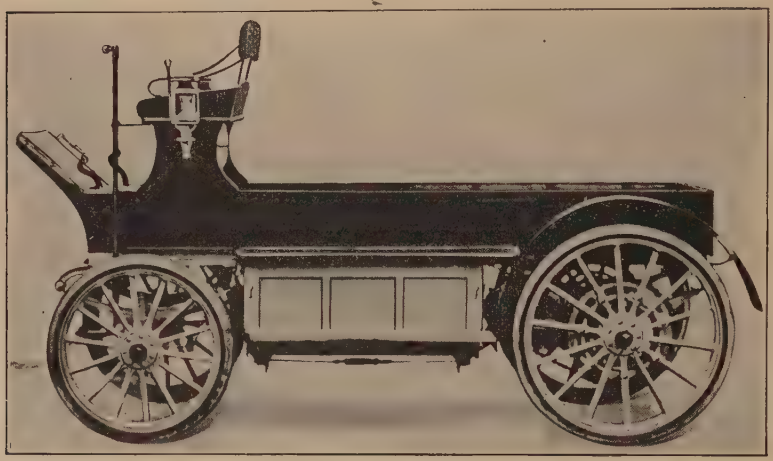


Fig. 2. Studebaker 1500-Pound Convertible Station Wagon.

and sprockets. They are equipped with 42 cells of Exide lead-plate battery, or of the National battery. The dimensions of the 1,200-pound delivery wagon are: 91-inch wheel base, 60-inch tread, with

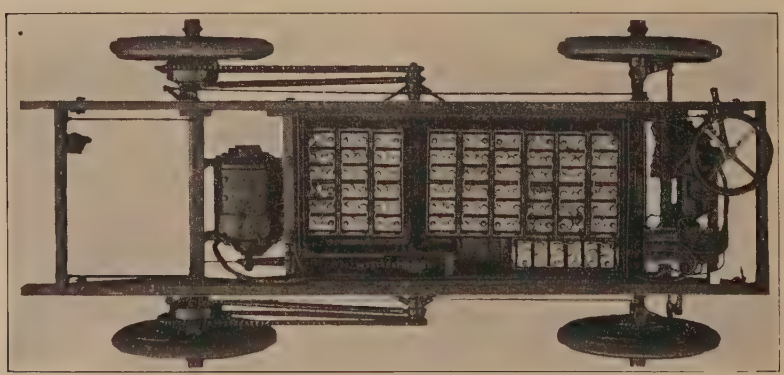


Fig. 3. Lansden Delivery Chassis.

32-inch front and 36-inch rear wheels, equipped with 3-inch solid rubber tires. The suspension takes the form of semi-elliptic springs in the front and full elliptic in the rear, the brakes being of the conventional internal expanding type in drums on the rear hubs, sup-

plemented by a countershaft brake. The axles are plain drop-forgings, the differential being placed in the countershaft. Steering is by wheel, which controls a gear of the pinion and sector type.

The Lansden delivery wagons represent a departure from the conventional type in several respects. In the first place, they employ a 60-cell Edison battery, instead of the usual lead-plate type. Though considerably lighter, this cell has a much lower voltage than the lead cell, which accounts for the greater number employed and the extra space required on the vehicle as shown by the chassis plan view of a Lansden, Fig. 3. It will also be noted from this that a single motor is employed, wound to take current at 72 volts. It is located at the rear of the chassis and drives forward by means of a single chain to a countershaft. The latter, instead of being of the round or square section ordinarily employed, takes the form of a flat bar 2 inches wide by $\frac{3}{8}$ to $\frac{1}{4}$ inch thick, according to the power it is to transmit. The material is spring steel, so that the countershaft acts as a cushion to prevent the stresses of starting from being transmitted to the tires and the mechanism of the car, and it has proved unusually effective for this purpose. From this countershaft, the final drive is taken to the rear wheels by long side chains of the usual roller type. The countershaft also embodies the differential, so that the axles are plain, the wheels being carried on long bronze sleeve bearings. The steering wheel is placed on the left-hand side and the steering column carries the controller lever. The brakes in the rear hubs are operated by a pedal. The appearance of a complete delivery wagon of the Lansden type may be judged from Fig. 4.

The load capacity of this wagon is 1,500 pounds and it has a radius of 40 miles on a single charge of the battery at an average speed of 11 miles an hour. The weight of the complete vehicle is 3,000 pounds, its wheel base is 88 inches, its tread 56 inches, and the tire equipment consists of 32-inch by 3-inch solid rubber tires all round. The vehicle is operated by means of a special form of continuous torque controller, giving three or four speeds forward, as desired by the purchaser, and two speeds on reverse.

Range of Usefulness of the Electric Delivery Wagon. It has been regarded as a generally accepted fact in the past that the usefulness of the electric delivery wagon must, of necessity, be limited to strictly city service, where the routes are well paved and the run does not

Fig. 4. Lansden Electric Delivery Wagon.

involve traveling more than 30 to 35 miles a day at the most—at least, without affording an opportunity for a stop during the lunch hour in order to give the batteries a "boost," at some convenient charging station. This was quite true in earlier days and the distances were even shorter for a day's work, but considerable improvement has been made both in the vehicles generally and the batteries since then. As a result, it has become possible to employ electric delivery wagons to great advantage in suburban service, and what would have been considered remarkable records not long ago are now matters of course.

For example, a 1,000-pound Lansden delivery wagon—equipped with one of the new Edison nickel-iron batteries of 65 cells, weighing 700 pounds—operating constantly in the service of one of New York's largest drygoods houses, which regularly maintains 41 electric and gasoline machines in addition to 100 head of horses, covered 45 miles over heavy, muddy roads and made 175 stops for package deliveries on the trip to Coney Island and return. The same wagon was later transferred to a route on the Jersey side of the Hudson River, extending down the Bergen Point peninsula to Bayonne, and regularly served a route of 43 miles, calling for an average of 125 daily deliveries, without requiring any "boosting" of the battery.

In the service of the same house, a Lansden 2,000-pound capacity wagon, weighing 2,460 pounds, and equipped with a new Edison battery, weighing 1,200 pounds, ran 93 miles on three consecutive days, making an average of 100 stops per day, on a single charge of the battery. The first two days' run were to Bergen Point, and the third to Staten Island, where the roads are very hilly, though generally of good macadam construction. The same wagon and battery, operating in the service of the Macy department store in May, 1909, made a trip to Morristown and return, covering 72 miles over hilly roads and making 45 deliveries, on a single charge. On another occasion, it was sent to Tottenville, Staten Island, over equally hilly roads, making 60 stops and covering 56 miles on one charge. In regular daily service, this wagon makes 56 to 57 miles a day on an average without any necessity for boosting the battery, returning to the garage at night good for 10 to 12 miles more. Its working time has averaged 14 to 18 hours a day, being recharged during the night at a 40-ampere rate for six or seven hours.

The delivery experts of the two establishments in question are of the opinion that this wagon is easily capable of covering the longest and hardest routes operated out of New York City by any company, and that the capacity of the wagon is far in excess of the endurance of the driver and helper. It must be admitted that these are exceptional records for electric vehicles and surpass the capabilities of the heavier types propelled by lead storage batteries, but they are sufficient to demonstrate that the electric is not a strictly city-service machine and likewise that as a class, the electrically-driven vehicle is not the decadent type that many suppose it to be.

ELECTRIC TRUCKS

In the classification of vehicles as listed by some manufacturers there is more or less difficulty in drawing a distinct line between the delivery wagon and the truck, as a 2,000-pound delivery wagon chassis when fitted with what is known as a *stake body*—that is, an open platform with removable stakes for holding on the load—is frequently listed as a "light truck." It is the same chassis as that on which the delivery wagon body is mounted, and is simply fitted for transporting a different character of merchandise, usually goods in cases or in bulk. Between the light truck and the heavier vehicle intended for the same general service, the chief difference is that of dimension, even up to the 10,000-pound, or 5-ton truck, which is about the maximum that has been found practicable for electric propulsion.

There is little, if any, difference in design, the frames, axles, wheels, springs, and transmission simply being made heavier in proportion to the great increase in load to be carried, while there is a corresponding difference in the power of the motor or motors and in the size of the chains or other essentials of the transmission. As already mentioned, some makers, such as the General Vehicle, adhere to the single motor power plant even in sizes up to 2-ton and 3-ton capacity, on the score of increased economy and higher efficiency, while others, such as the Studebaker, employ two motors on vehicles as small as the 2,000-pound size.

The dividing line between the capabilities of the electric and gasoline vehicle for the transportation of heavy merchandise, in large quantities, is more sharply drawn than where lighter types of the

two are concerned. It has been demonstrated that the electric delivery wagon is capable of performing more work in the course of a day than lies within the capacity of the driver, while its average speed is quite up to that usually permitted by legal restriction in urban and outlying communities. It has the advantages already pointed out of being handled by an unskilled driver and is not subject to the latter's lack of knowledge to the same extent as is the gasoline-driven car, the adjustments of which may be easily tinkered with and are not difficult to derange, so that it appears quite probable that both types will continue as active competitors in this particular field.

Power Limits. The matter assumes a totally different aspect as weights increase, owing to an inherent shortcoming of the electric vehicle, viz, lack of power capacity. The amount of energy that can be chemically converted and held in reserve by the battery for use in the motors has very sharply defined limits. Weight of the battery itself is naturally the principal factor that determines this, and, beyond a certain point, its increase is totally disproportionate to the gain in capacity. As this has a direct bearing on the load efficiency of the vehicle itself, *i. e.*, the amount of useful load it can transport as compared with its own weight, there is a still further limitation. This will serve to explain why it has not been found practical to build electric vehicles with a capacity exceeding five tons. It may be added here, that a comparatively small number of the latter has ever been put in service, and as an electric vehicle of this size forms such a close approach to what experience has demonstrated to be the available limit of usefulness for this method of propulsion, that its use is seldom considered favorably by transportation experts.

Next to the delivery wagon, in which electric power has scored its greatest success, trucks of 2-ton and 3-ton capacity are the most common forms of electric vehicles. In order to obtain the increase in load-carrying capacity, the size of the motor must naturally be enlarged with a corresponding increase in the power consumption, which calls for a very much larger battery. In order that the capacity of the latter may be sufficient to give the vehicle a practical radius of travel on a single charge, without unduly adding to the weight, the speed is reduced, and electric trucks of 2-ton capacity usually have an average speed of 8 to 10 miles an hour; 3-ton trucks, 6 to 9 miles an hour, and 5-ton trucks seldom exceed 6 miles an hour. Even

at these low speeds, it is difficult to obtain a daily mileage exceeding 20 to 25 miles on a single charge of the battery, and where the latter is of the lead-plate type and has been allowed to fall off in efficiency through deterioration or careless handling, they will not accomplish that distance on a single charge, without resorting to "boosting" the battery. This means giving the battery a heavy charge, *i. e.*, sending current into it at a high charging rate for a short period before it is more than three-quarters discharged, in order to enable the vehicle to return to its garage. As will be noted in the chapter on the subject of charging the batteries, this is poor practice and is detrimental to the battery. A route should not be served by an electric vehicle whose capacity is not sufficient to cover the distance without resorting to boosting.

Some examples taken from actual practice will best serve to illustrate the foregoing. For example, take the Studebaker baggage transfer wagon, Fig. 5. This is rated as having a useful load capacity of 2,500 pounds. According to the makers, this is a "teamster's rating" and the wagon is designed to give good service with frequent overloads ranging as high as 100 per cent, on the assumption that the average load, year in and year out, will not exceed 2,500 pounds. It must naturally be borne in mind, however, that the speed and traveling radius are limited entirely by the load carried. For instance, this wagon has a speed of $9\frac{1}{4}$ miles an hour on good, hard, level roads, with an average load of two-thirds its rated capacity. It will be noted that this machine properly falls within the light truck class and the manufacturers offer it either in the form illustrated, or with a delivery body. Its construction is along conventional lines, employing a pressed steel frame, semi-elliptic springs, and drive by two motors with a single-speed reduction by chains to the 42-inch driving wheels, in accordance with the usual Studebaker practice. The front wheels are 36 inches in diameter, the wheel base is 104 inches, and the battery complete is suspended from the frame in a substantial battery box, hung just forward of the motors. Doors at the side permit the withdrawal of the battery in trays as usual. The dimensions of the load-carrying space are 115 inches in length by 43 inches in width for the open wagon, and 63 inches in height, when a delivery body is employed.

Next to the type just described is the Studebaker 4,000-pound

Fig. 5. Studebaker 2,500-Pound Express Wagon.

Fig. 6. Studebaker 7,000-Pound Special Electric Wagon.

stake truck. This is also a teamster's rating and the vehicle is capable of frequent overloads not exceeding 50 per cent of its normal capacity, under conditions similar to those already referred to in the case of the lighter vehicle. Its speed with two-thirds of its rated capacity on level, hard roads, is the same as before, *i. e.*, $9\frac{1}{4}$ miles an hour. It has a wheel base of 117 inches, gauge of $62\frac{1}{2}$ inches, and is fitted with 36-inch artillery wheels, front and rear, the tires on the rear being of the twin type, measuring $3\frac{1}{2}$ inches in diameter, while the forward ones are 5-inch single, solid rubber tires. The dimensions of its load-carrying space are 156 inches long by $49\frac{1}{2}$ inches wide.

So far as their appearance is concerned, the Studebaker 7,000 and 10,000-pound electric wagons, do not differ materially from the

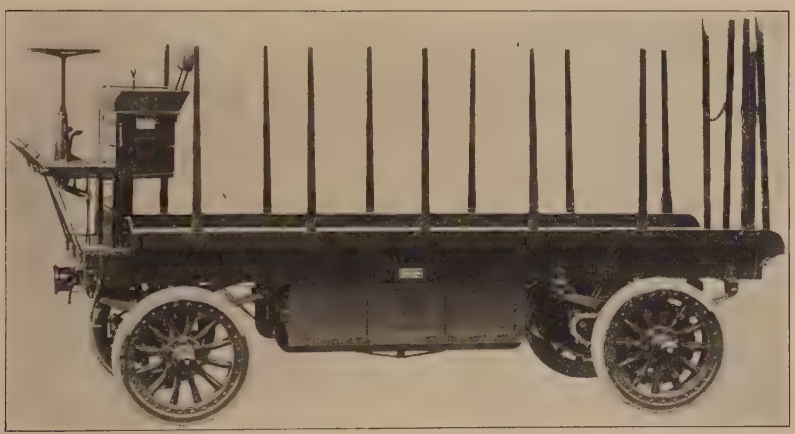


Fig. 7. Studebaker 10,000-Pound Stake Truck.

2-ton size. Their speeds are respectively 9 miles and $7\frac{1}{2}$ miles an hour, these being the maximum with two-thirds capacity, as before, the average rate of travel naturally being less. The wheel base is 127 inches in the smaller, and 126 inches in the larger, with gauges of 75 inches and 76 inches respectively; 36-inch wheels are employed throughout on the running gear; the only difference being in the size of the tires, which are 4-inch twin type on the rear in both cases, with 5-inch single forward on the smaller, and 7-inch on the larger truck. The load platform dimensions of the $3\frac{1}{2}$-ton truck are 157 by 56 inches and for the larger, $169\frac{1}{4}$ by $58\frac{1}{2}$ inches. A Studebaker 7,000-pound wagon is shown, in Fig. 6, while the 5-ton wagon of the same make is shown in Fig. 7. One of the latter is

employed by the U. S. Government in connection with the Marine Arsenal at Washington, D. C., and renders excellent service in the transportation of heavy forgings and other gun parts.

Service. Some idea of the service rendered by an electric vehicle in strictly city use may be gained from the work accomplished by a Studebaker 1,500-pound delivery wagon of the type shown in Fig. 8. This wagon was in service steadily for 15 months and was never idle except when the batteries were being washed. It was kept running seven days a week, and frequently at night in addition, and during

Fig. 8. Studebaker 1,500-Pound Delivery Wagon.

that time averaged 24 miles a day. One of the 2,500-pound size averaged 32 to 35 miles a day on a single charge of the battery, making a total of 1,000 miles a month of city travel for four months' running. This car was also fitted with a delivery wagon body of the usual enclosed type. One of the numerous styles of bodies available is shown in Fig. 9, which is a small sight-seeing 'bus mounted on a 1,500-pound capacity chassis.

Heavy Types. As further examples of the heavier types of electric trucks, there may be cited the Waverly two- and three-ton

sizes. These trucks are fitted with a battery of 42 Exide cells having large plates and are equipped with a G. E. motor driving the rear wheels through the medium of one gear reduction, through herringbone pinion and gear, and a first speed reduction through a chain. In other respects, their construction is substantially the same as in the case of the vehicles just described. The 2-ton Waverly truck has a 111-inch wheel base with 73-inch gauge, while the 3-ton size measures 118 inches on the wheel base, the tread being the same. Both bodies have been designed for merchandise of an intermediate character, where weight is concerned,

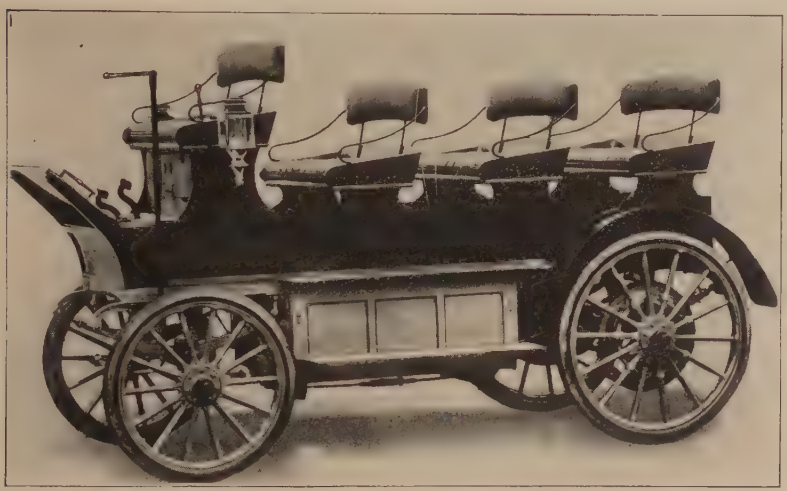


Fig. 9. Studebaker 1,500-Pound Convertible Station Wagon.

and the load space is accordingly very large, being 192 inches by 72 inches by 84 inches high, in the 2-ton, and 156 inches by 54 inches by 72 inches high in the larger. Trucks of this make are distinguished by a silent chain drive from the motor to a short countershaft, constituting the first speed reduction The motor itself is placed closer to the rear axle than is customary in most other types and the silent chain is very short. This countershaft is equipped with a universal joint close to each end, while at each extremity it carries a pinion meshing with a gear on the axle itself. The gearing is very silent and efficient and is of the herringbone type in which the teeth are of widened V form.

The electrics listed by the General Vehicle Company afford an excellent example of a standard design of chassis applied to cars ranging from 1,000 pounds capacity up to 5 tons, the intermediate sizes being 2,000 pounds, 2 tons, and 3½ tons. The first two are naturally delivery wagons and are capable of traveling 45 miles on a single charge of the battery at a maximum speed of 11 and 10 miles per hour respectively. The 2-ton wagon, while capable of the same mileage, has a maximum speed of but 9 miles per hour. This is further reduced to 8 miles an hour for the 3½-ton truck, which has a radius of but 40 miles on a charge, while the 5-ton truck travels but 7 miles an hour as a maximum and has an extreme radius of but 35 miles on a charge. In every case, but a single motor is used, and as the design in all other respects is also standard for all sizes, a description of the 2,000-pound wagon will suffice.

Fig. 10. General Vehicle Company Pressed Steel Frame.

With the exception of the use of a single-motor drive, a large number of the parts employed are practically the same as those used in other makes of electrics. The foundation of the entire car consists of a pressed steel frame, Fig. 10, to which is directly riveted the cradle for carrying the battery, the spring hangers, and the supports for the countershaft bearings. The view of the complete chassis given in Fig. 11, is taken from below and illustrates every essential except the battery. From left to right there are the semi-elliptic rear springs, the solid steel rear axle, artillery wheels with solid rubber tires and large driven sprockets, driving chains, the single motor suspended directly from the frame, the silent chain drive from the motor to the countershaft, the terminal board for the wiring from the controller to the motor, and the countershaft with its radius rods to equalize and maintain its distance from the rear axle. These rods also serve to take the stresses of driving off the rear springs. Just in front of the countershaft is the steel cradle for the battery trays, then at

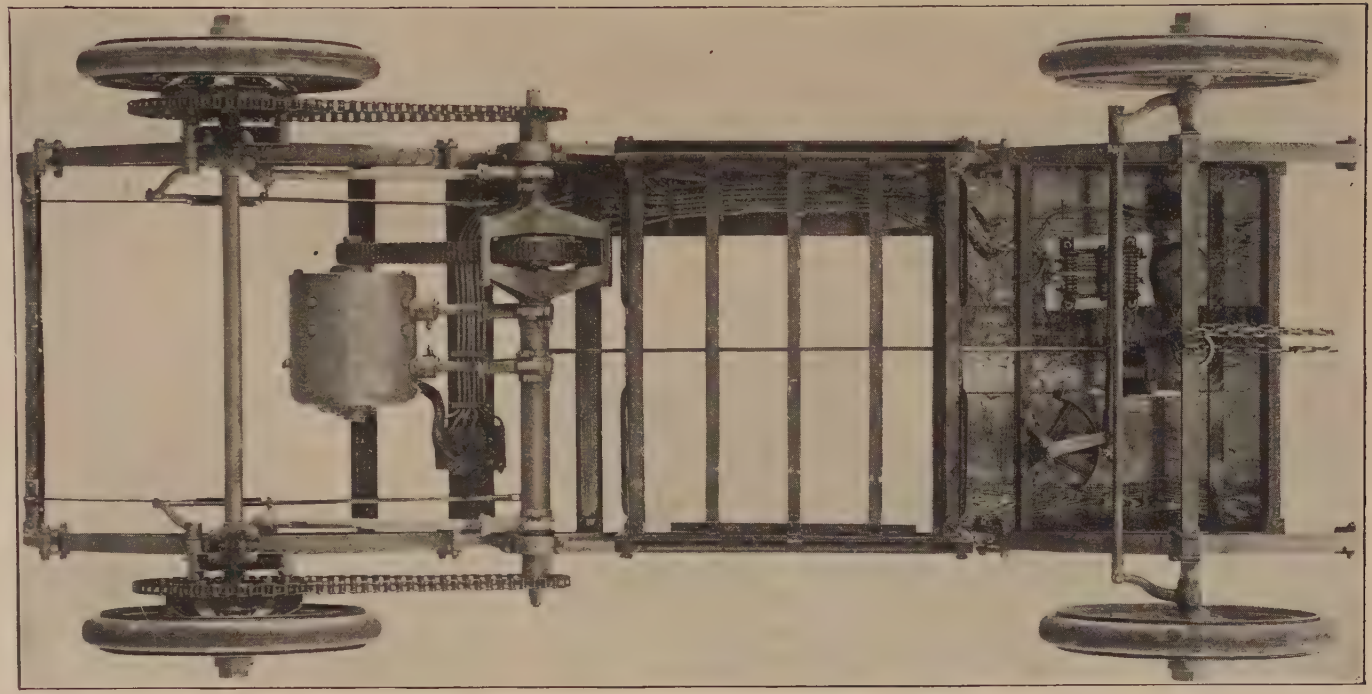


Fig. 11. General Vehicle Complete Chassis—Taken from Below.

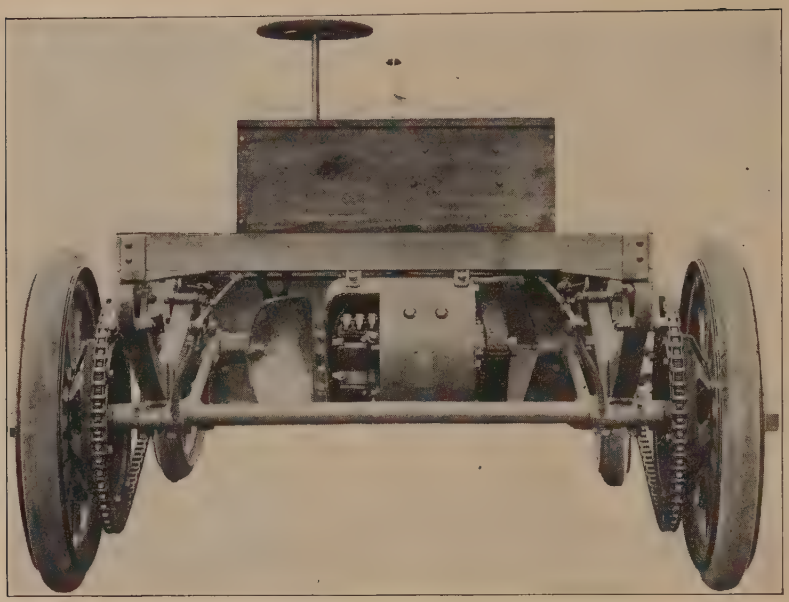


Fig. 12. General Vehicle Company Chassis—Rear View.

the lower side the steering gear, and at the upper a resistance, and the bell, the forward axle, springs, wheels, and so forth.

An excellent view of the entire rear construction which gives a

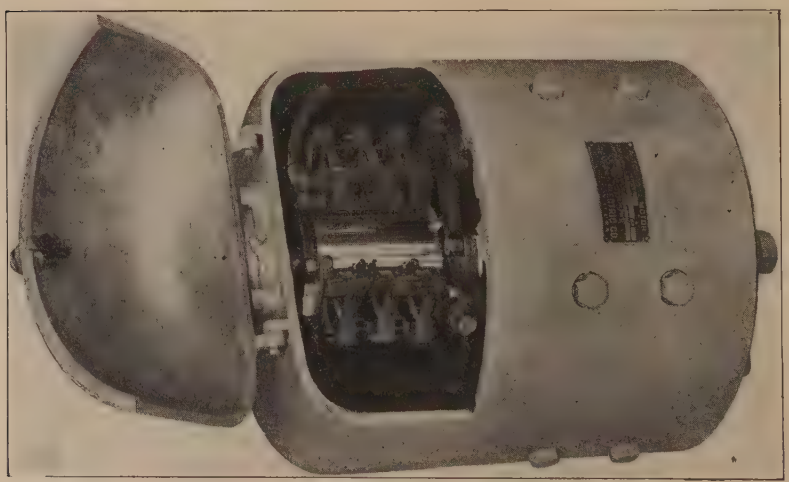
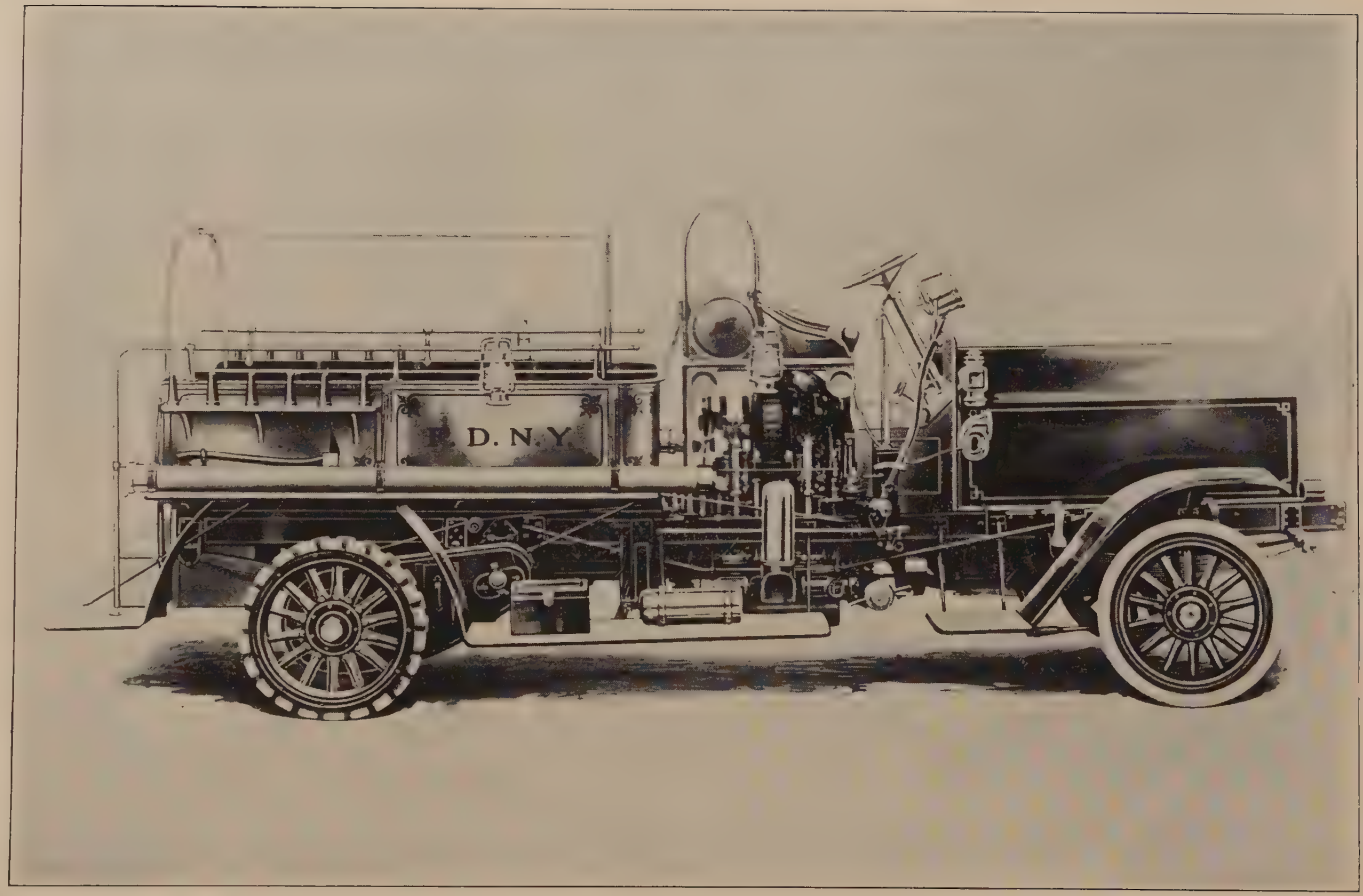


Fig. 13. General Electric Motor.



KNOX MODEL 9 FIRE PUMP—CAPACITY 1000 GALLONS PER MINUTE

Knox Automobile Company, Springfield, Massachusetts

clear idea of the arrangement of the power and the drive, is shown in Fig. 12, while the essentials comprising it are shown in detail in Fig. 13—which is the G. E. multipolar, ironclad motor—Fig. 14—the countershaft with its supporting housing—and Fig. 15—the same

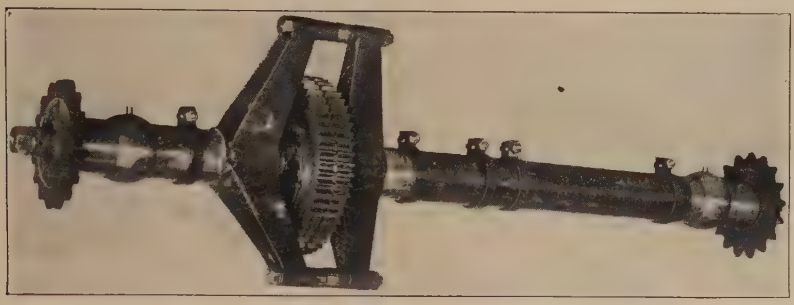


Fig. 14. General Vehicle Company Countershaft and Housing.

part, showing the differential driving shafts and sprockets as well as the two types of chains employed. Fig. 16 shows the rear axle, and Fig. 17, one of the rear wheels with its attached sprocket, while the

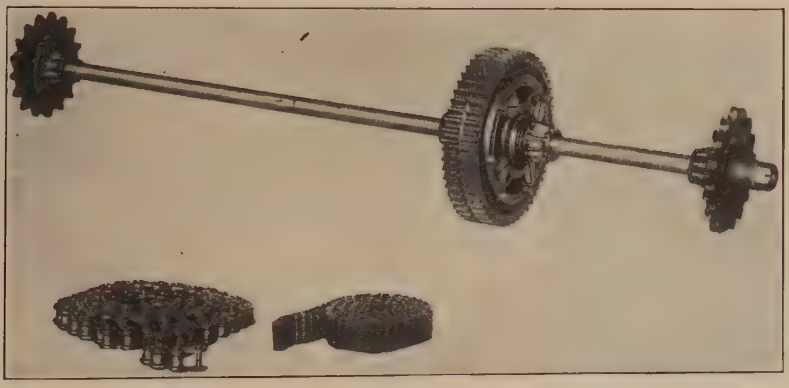


Fig. 15. Countershaft without Housing Showing Differential Gears and Chains.

forward axle and its steering attachments is shown in Fig. 18. The type of controller employed, together with its operating lever, is shown in Fig. 19, while Fig. 20 illustrates the usual charging plug connection used on commercial electric vehicles.

Battery Specifications. A 44-cell storage battery furnishes current at 85 volts, the motor being wound to operate economically at this voltage. The battery is in sectional form in crates of such

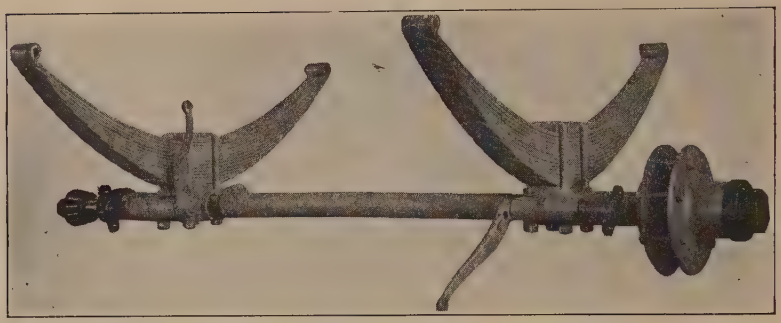


Fig. 16. General Vehicle Company Rear Axle.

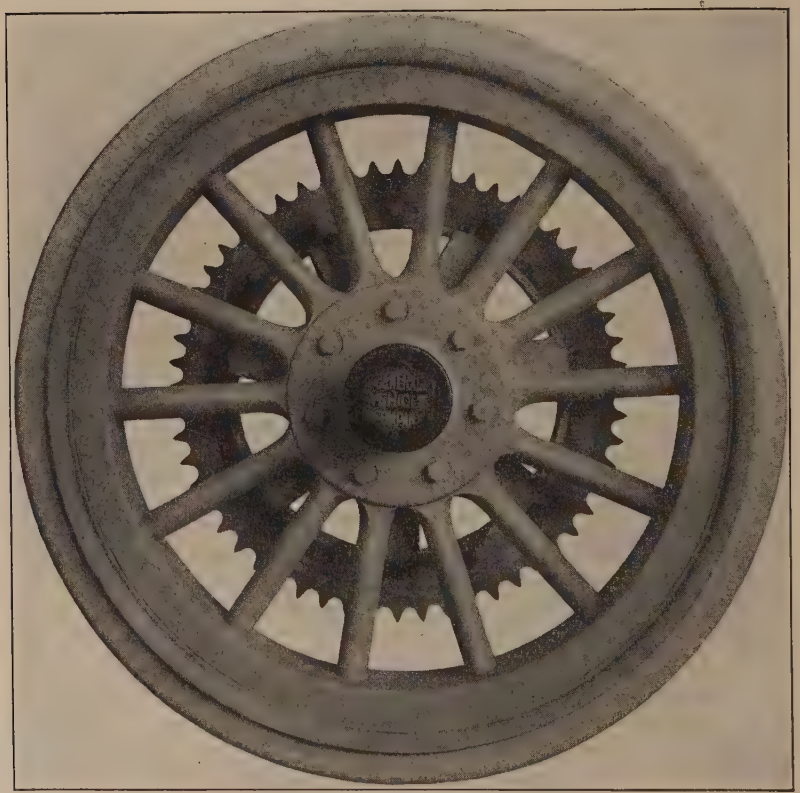


Fig. 17. Rear Wheel and Sprocket.

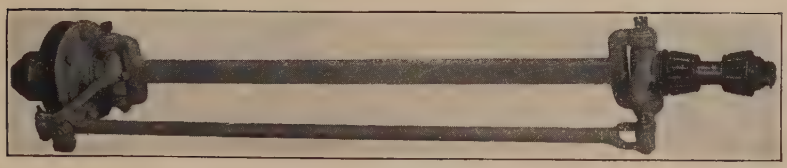


Fig. 18. General Vehicle Company Front Axle.

weight and size as to permit of easy removal or replacement from either side of the vehicle. It is so arranged that it may be recharged without disturbing it, but where two batteries are employed, a charged set may be easily and quickly substituted for the exhausted battery.

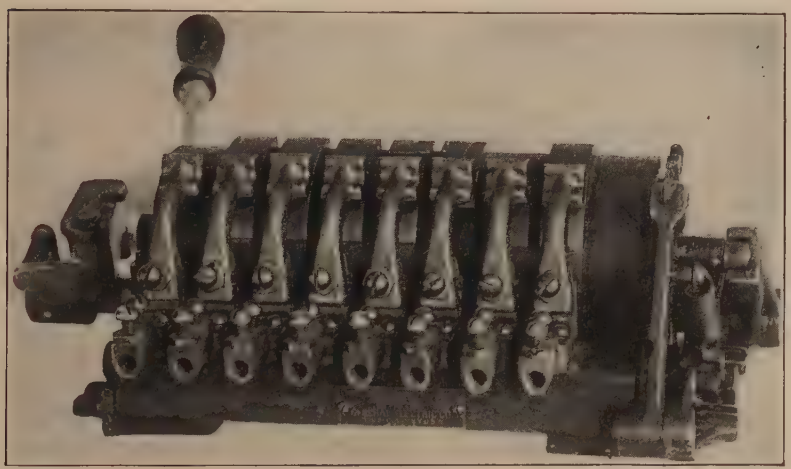


Fig. 19. General Vehicle Controller.

The controller is of the continuous torque type, which permits of changing the motor speeds by degrees without interrupting the power between any of the steps. This gives a gradual and steady acceleration,

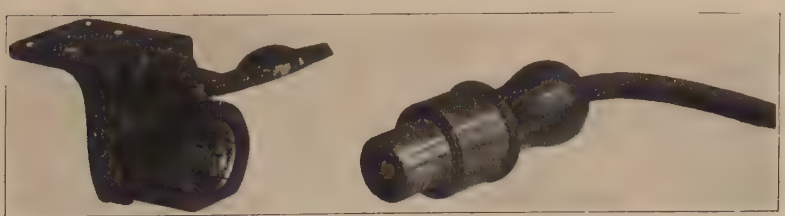


Fig. 20. Charging Plug.

without jerk or strain, which are detrimental to the life and efficiency of every part of the vehicle. The motor is designed along the same lines as have proven so successful in street railway work. It has a very heavy shaft, simple and durable brush rigging, and is wound to show not alone a high efficiency, but also a high capacity for overload. The armature shaft is carried on annular ball bearings which tend to greatly increase the efficiency of the motor as a whole. It is suspended on a transverse bar pivoted to the side members of the frame, forward of the rear axle. This pivoted suspension keeps the motor shaft parallel with the countershaft throughout the entire range of chain adjustment and permits the use of an efficient silent chain drive.

Transmission. The entire countershaft is housed-in and is carried on four taper roller bearings inside the tube, the latter being held in self-aligning ball sleeves in hangers riveted to the sides of the frame. The two short driving shafts are connected by a spur differential and carry at their outer ends small sprockets for the roller chains to drive the rear wheels, the entire countershaft being a complete unit. It is driven by a silent chain of ample width running over a small pinion on the motor and the gear of the differential. The battery capacities are 112 ampere hours for the one- and two-thousand-pound delivery wagons, the motor of the former developing its power at 2,000 r. p. m., while all the others run at 1,200 r. p. m. The 2-ton truck has a battery capacity of 168 ampere hours, the 3½-ton truck, 196 ampere hours, and the 5-ton truck, 280 ampere hours. The controller in every case, provides four speeds ahead and two reverse.

SPECIAL FORMS OF THE ELECTRIC

Couple-Gear Truck. Owing to the ease and directness with which the power may be applied, electricity lends itself admirably to special forms of construction, a particularly ingenious example of which is to be found in the drive of the Couple-Gear truck—so-called because all four wheels are driven by electric motors and all are utilized for steering purposes. These vehicles are built as straight electrics, using a storage battery as the source of current; and as gas-electric vehicles, a gasoline engine and generator forming the power plant, the remainder of the design and construction being the same in both cases.

The motor is built directly into the wheel, as will be apparent from the illustration of a dismounted wheel shown in Fig. 21. The motor is of bipolar type, designed with flat fields in order that it may fit within the wheel without unduly increasing its section and is held by its attachment to the axle. The wheel accordingly revolves about the motor, being driven by the two small pinions noticeable on opposite ends of the armature shaft, and which mesh with the circular racks attached to the periphery of the wheel. The brushes are carried in a yoke bolted to the outer half of the field casting, so that the removal of the latter makes everything accessible. The appearance of the complete wheel, minus its tire, will be apparent from Fig. 22, which shows it end on, and also serves to illustrate the drive, one of

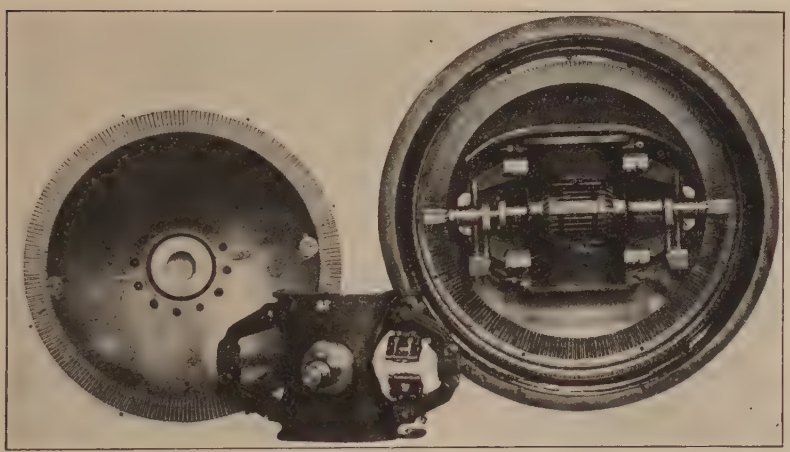


Fig. 21. Dismounted Couple-Gear Truck Wheel Showing Motor Parts.

the pinions meshing with a rack on the inner half of the wheel, and the second with the outer half. The electric cables for conveying current to the motor are led through the hollow axle. Apart from this feature and the employment of a four-wheel steer, the vehicle itself follows more or less conventional lines.

Lansden Scenery Wagon. The scenery wagon, Fig. 23, has a load capacity of 4,000 pounds and measures 20 feet 6 inches over all; it is also designed to haul a small trailer behind it to support the unusually long scenery employed in the Metropolitan Opera House. The tread is 66 inches, and the wheel base 148 inches, and

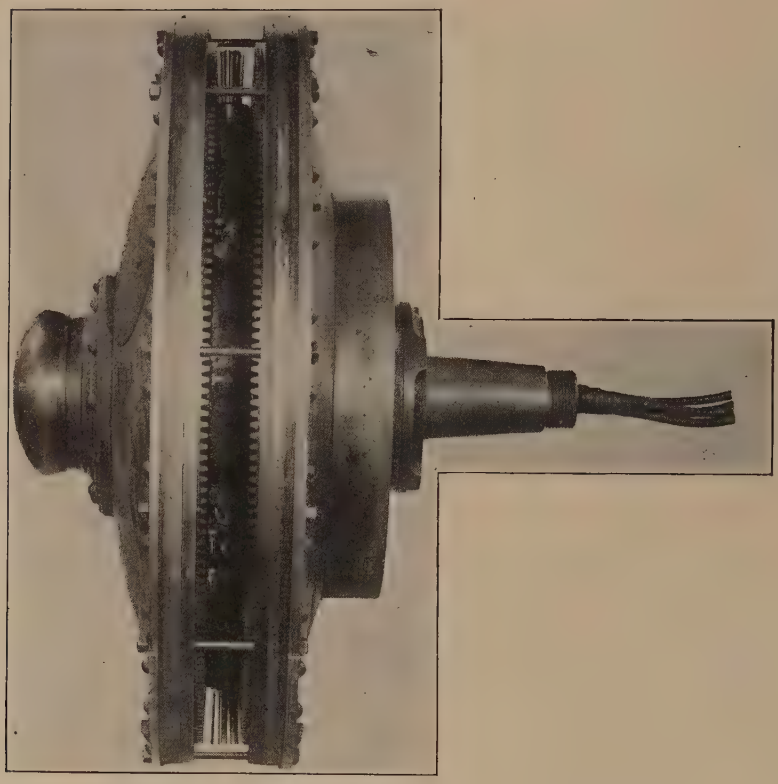


Fig. 22. Assembled Couple-Gear Wheel with Tire Removed.

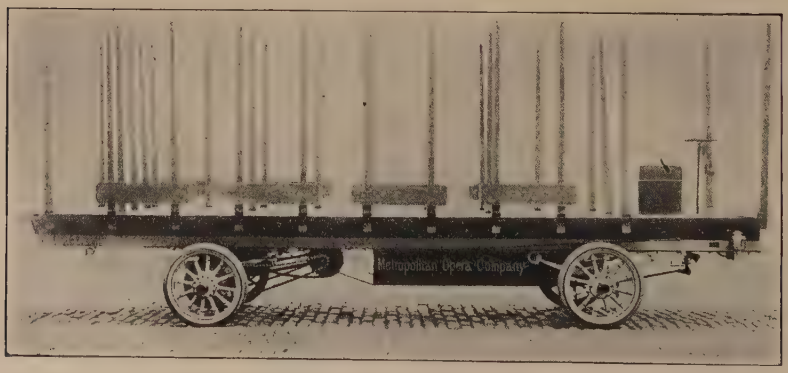


Fig. 23. Lansden Special Scenery Wagon.

Fig. 24. Electric Dock Trucks.

the weight of the vehicle 5,000 pounds; the tires are 32-inch by 4-inch solid rubber, and the chassis in other respects is of the same construction as the regular delivery wagons listed by the same makers. The motive power is a single motor fed with current from a 60-cell Edison battery.

Dock Trucks. A special and very serviceable type of electric truck has been developed for use in handling cargoes. Fig. 24 shows two of these trucks in action, and gives an excellent idea of their characteristics. These dock trucks are built on a special convertible system by which they may be readily supplied as either single or double-ended cars. A plan view of the double-ended type of chassis is shown in Fig. 25. One of the special features of this

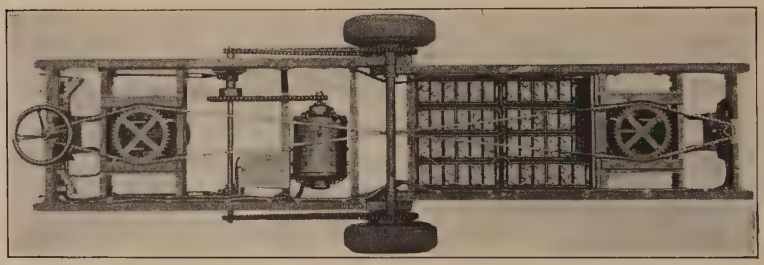


Fig. 25. Double-Ended Dock Truck Chassis.

vehicle is the fact that it may be interchangeably driven from either end, by simply lifting out the steering column which carries the wheel and controlling lever with it. There is a controller at each end and a special switch governing the direction in which the vehicle will run. The method of interchangeable steering will be apparent at a glance at the illustration. The load capacity of these trucks is 4,000 pounds and they are capable of running 18 miles on a charge of the battery at a speed of $4\frac{1}{2}$ miles per hour. The weight of the car complete is 2,750 pounds. The driving wheels, 24 inches in diameter, and shod with 6-inch rubber tires, are placed in the center of the chassis, while at each end a single steering wheel of smaller diameter is provided with steel tires. The platform space is 14 feet 6 inches long by 4 feet broad, and stands 28 inches above the floor. Several of the same type of truck are also in use as baggage transfer wagons in railway terminals.

GASOLINE VEHICLES

TAXICABS

Development. Looked upon generally as being nothing more or less than a slight modification of the pleasure automobile, the taxicab has, in reality, proved to be one of the most important factors in the development of the commercial vehicle as a type. Automobile designers were of the opinion at the outset that little else but size distinguished the touring car from a vehicle adapted to public service. European designers undertook to proceed along this line as far back as 1904 and were grievously misled thereby. It did not take long to demonstrate that there was a world of difference between an automobile intended for occasional service, even though the latter be hard, and one that would be called upon to work ten to eighteen hours a day, in all kinds of weather, and every day in the year.

New York was really a pioneer in the adoption of the motor-driven cab, as they were to be seen on the streets of this metropolis as early as 1899. They were not taxicabs, simply because they were not provided with the distance- and time-recording meter that has been responsible for the creation of that appellation, but they were probably the first motor-driven vehicles to be employed in this service. Electricity formed the motive power and the vehicles themselves were of the hansom type with the driver seated on top or behind, according to the precedent established by the horse-drawn hansom; later, coupés, victorias, opera buses, and the like, were used.

These vehicles were placed in service at a time when neither the batteries nor the method of transmitting the power to the road wheels had reached a high state of development; they were accordingly inefficient as compared with later-day cabs, but they were very solidly built, as is shown by the fact that many of them are in active service right up to the present. That their earning power is low as compared with the gasoline vehicle, due to the higher cost of operation, goes without saying, but they appear to be destined to remain in service for some time, so far as can be judged at the present writing. When first employed, the electric vehicle was the only type that could be depended upon to provide reliable service, and the delay in adopting gasoline-driven cars for this service was a result of their shortcomings in this respect. Only one company attempted their use on

any scale in this country, and was responsible shortly afterward for their introduction abroad.

Despite the numerous points of similarity between the average touring car and the public service vehicle, French designers, who were the first to attempt a gasoline taximeter cab service, found that there were many lessons to be learned. These first attempts were accordingly not always of the most profitable nature, but they served to give their promoters much valuable experience upon which later developments have been based.

The gasoline taxicab was not introduced into this country until 1907, and, as was to be expected, the first cabs came from abroad, a company starting in New York with about 150 vehicles the first year. How great has been the growth in the few years intervening is illustrated by the fact that New York alone now has more than a dozen companies operating between two and three thousand cabs—which are not always sufficient to supply the demands by any means.

Competent Drivers. With the taxicab, just as with all other gasoline-driven vehicles in the commercial field, the procurement of a sufficient number of skilled drivers to handle the cars proved at the outset a greater difficulty than the designing of a car suited to the service. In view of the extremely rapid growth, the demand for such men has naturally been entirely disproportionate to the supply, applicants in a very large number of instances being nothing more than hack drivers whose only asset is a chauffeur's license from the state.

The capacity for destructiveness of the green drivers was further added to by the system of remuneration first in vogue—that of paying the driver entirely on a commission basis. In New York, this was 20 per cent of the net earnings of the cab, the driver paying for the fuel used at cost; while in Europe a nominal wage was paid, supplemented by percentages on a sliding scale in accordance with the earnings of the cab. In every case, this was controlled by the taximeter which provided an accurate check on the day's work by recording the total distance run and the sum received by the driver.

Taximeters. The Jones taximeter, Fig. 26, was the first instrument of the kind to be manufactured in this country, and as all taximeters work on the same principles and are substantially alike in construction, it will be unnecessary to refer to others. A series of

Fig. 26. Jones Taximeter.

numbered dials, carrying the figures on their edges, are actuated according to their decimal values on a dollar basis, by a flexible shaft connection with one of the wheels of the cab. Formerly one of the driving wheels was utilized for this purpose, but due to the slip of the latter on wet pavements or ice, a mileage greatly in excess of that actually traveled was often recorded, and the objection raised by the public was so general that the driving mechanism was transferred to a front wheel. As is the case with the ordinary speedometer, the instrument's working is based upon the diameter of the wheel by which it is driven. For instance, assuming the circumference of a 30-inch wheel to be 90 inches—in round numbers for the sake of illustration—it would make 704 revolutions per mile, no deduction being made for slip. This number of revolutions would cause the first dial to revolve once and the rate per mile to appear at the first opening. For example, on a basis of 30 cents per mile, the latter sum would show; but as this is the minimum charge, the taximeter is arranged so that when the engaged lever is put down, this charge appears. After the first mile the dial is arranged to record quarter miles, at the rate of ten cents, usually. Extras, such as carrying baggage or going beyond the limits of certain districts, are manually recorded on the taximeter by the driver, and a second series of recording dials, the figures of which are visible through openings in the rear of the instrument, indicate the total amount received.

Operating Costs. *Repairs.* While from the first, earnings have been large, some of the drivers have been able to damage the cars faster than the shops could repair them; and the lack of experience in the handling of the machines has also resulted in frequent accidents, so that operating costs have been correspondingly high.

Immunity from repairs, or at least a reasonable freedom from breakdown, is of vital importance in the operation of any commercial vehicle, but especially so in the taxicab. These little cars average 80 to 100 miles per day, and in the hands of particularly ambitious drivers have been known to run as high as 125 to 150 miles for days in succession. As the driver is working in his own interest, he is naturally tempted to get there and back as quickly as possible, in order to cut down his waiting time to the minimum. The result in the first year of operation was a list of repair charges that was appalling. Stripped gears, battered radiators, damaged bodies, and the

like were of such frequent occurrence that a considerable percentage, in fact, an excessive fraction of the total equipment was always in the shop. Seized motors were not unknown as factors in this list, as some of the novice drivers found even the absolutely simple lubricating system employed beyond their comprehension. This trouble was so general that a rule was enforced making it compulsory for the driver to always feed sufficient lubricating oil to keep the motor smoking. Such a procedure would have led to endless trouble in Paris where it is a misdemeanor to permit smoke to issue from the muffler; but in New York no such ordinance existed, and with the increase in the number of cabs, the smoke nuisance became flagrant, for the companies found it more economical to let the motors smoke, due to the excessive lubricant, and give them a periodical overhauling and cleaning, rather than to be called upon to repair them at short intervals owing to a lack of oil.

Tires. The advent of the taxicab in large numbers also served to give the pneumatic tire an entirely new status. Previous to that time, this was generally looked upon as the most unreliable and costly part of an automobile; but for commercial service, pneumatic tires are not bought outright as is the case with the individual user. The companies contract with the tire manufacturer for their equipment entirely on a mileage basis. That is, the tires are supplied as often as needed, compensation being calculated only on the mileage they run, so that whether a tire gives long service or fails after a very short time, it does not cost the user any more, every tire being numbered and a record of its mileage kept by an employe of the tire maker, this being made possible by the taximeter. The system goes far toward showing how erroneous the prevailing impression of tire weakness is, as it proves that pneumatics may be guaranteed for a certain mileage on a working commercial basis. The recording instruments are also leased and are kept in order by the manufacturers. At the outset, delays from puncture were guarded against by providing all the cabs with a *Stepney spare wheel,* which consists of a special rim carrying an inflated tire and provided with lugs which permit it to be bolted directly to the wheel in a few minutes, but this does not appear to have met with general adoption. The spare wheel was put in place without attempting to remove the damaged tire, and the driver's instructions were to return to the station

for a new tire as soon as possible after the puncture occurs, though there is nothing to prevent the spare wheel from being run for considerable distances on either the front or rear wheels with perfect safety.

Requirements of Service. It may appear at first sight as if the foregoing were more or less irrelevant, particularly in a work devoted largely to design, but its bearing on the subject will be realized from the description of the cabs in use, both their design and construction having been influenced to a very great extent by the experiences outlined above. Either because they failed to recognize the limitations of the average touring type of vehicle for this purpose, or because they were too busy producing the latter to be able to devote attention to the development of a new type, American makers were not prepared to meet the demand when it first arose. As a result, foreign manufacturers supplied the first two American cab companies with their vehicles and in this manner obtained such a hold on the market that quite a substantial percentage of the entire foreign car imports have consisted of cabs for the past three years. Judging from the nature of the experiences related of their early use, it is evident that several things were demanded of the successful taxicab that were not of such great importance in the touring car. Chief among these is the requirement of absolute *simplicity*, which means the absence of all necessity, or, in fact, possibility of adjustment by the driver. Then follows *compactness*, *ease of handling*, and *ready interchangeability*, as in such strenuous service as the cab is called upon to perform, the need for repairs is more or less frequent, even in the hands of the most careful drivers.

Types. *Foreign.* Practically all of the first cabs to see service in this country were of French origin, these being, in the order of their numerical importance, the Darracq, De Dion, and Delahaye. It will be noticeable from the description of the Darracq and that of some of the more prominent American cars of this type, that makers in this country were quick to take advantage of the results of the experience of their foreign confrères. The Darracq motor is of the four-cycle, four-cylinder, vertical type, with the four cylinders, as well as a large part of the piping for the inlet and exhaust, cast in a single piece, a practice that has since been followed largely here, in light touring car, as well as cab, design. This eliminates prac-

tically 90 per cent of the usual piping, the inlet and exhaust passages being cored right out of the casting, the necessary cooling of the latter being obtained by casting radiating flanges on it. Only two short lengths of pipe are necessary between the water jackets and the radiator for the circulation of the cooling water.

Designed in this manner, the motor becomes virtually a block which is mounted so as to be readily taken off or replaced on the chassis, and as its cylinder dimensions are very small (3.3 inches bore by 3.9 inches stroke), the motor as a whole is very compact. Such cylinders as these appear puny beside those ordinarily employed in pleasure-car design, but the object has naturally been to keep the power and weight down to but slightly more than what are actually needed. A motor can only approach its maximum efficiency when run under an approximation to its full load, and where a large amount of excess power is provided for as in the touring car, this is not possible, particularly in city streets with their close speed limitation and frequent necessity for slowing down and stopping. This small motor develops 18 horse-power, which is ample, and is of course, very economical in its consumption of fuel and lubricating oil, which represent very substantial items of expense in the running of a large number of machines.

A Bosch high-tension magneto comprises the sole provision for ignition, thus reducing the wiring to the simplest terms. It is located under the exhaust manifold, an easily accessible, but out-of-the-way place, this being an otherwise bare side of the motor as all the valves are placed on the opposite side. The sparking point is fixed, but may be retarded for starting by pulling a small trigger located near the cranking handle, so that the entire control of the motor is centered in the throttle lever, which takes the form of a pedal, in order that the driver may have both hands free for steering and manipulating the change gear lever. Driving is thus reduced to steering, braking, and operating the clutch and gear-shifting lever.

The power plant, consisting of the motor and clutch forward, constitutes one easily handled unit, while the drive is a second, the gear box being mounted on the rear axle. Three speeds forward and reverse are provided, gear-changing being by means of the usual lever operating in a gate sector, and the entire transmission may be taken down or replaced with the same ease as the motor,

simplicity and interchangeability having been attained by uniting the differential and gearset in the same housing on the rear axle. In addition to the switch and pressure feed lubricator on the dash, there is a small lever by means of which the exhaust may be made to pass through a foot warmer in the floor of the body before reaching the open air. The wheel base is short and the frame is made as narrow as possible forward, so that the cab may be turned round in the ordinary narrow cross-town street without resorting to the reverse. This makes the cabs exceptionally easy to handle in congested traffic, these features having been brought about largely through the rigorous traffic regulations of the London police, as the first of these cabs were designed for service in that city.

American. The chief source of trouble with the majority of American taxicabs first placed in service was due to the fact that they were not taxicabs at all, but merely touring chassis fitted with landaulet bodies and taximeters—in fact, the addition of the recording instruments appeared to be the only thing necessary to accomplish the conversion. But the demand for power-driven, public-service vehicles has been so great that a large number of these makeshift cars have been run profitably.

The Thomas taxicab was one of the first of American production to be designed especially for this purpose, and as will be noted from its specifications, its builders were careful to follow the precepts learned through costly experience by foreign makers. It is equipped with a four-cylinder vertical motor cast *en bloc*, with the inlet and exhaust passages integral, the latter being cooled by radiating flanges cast right on it. The cylinder dimensions are $3\frac{3}{8}$-inch by $4\frac{5}{16}$-inch bore and stroke respectively, with an output of 16 to 20 horse-power. The valves are all placed on the same side and amply water-jacketed, as are also the exhaust manifold and the carbureter, the latter being of the simplest automatic type. The flywheel has blades attached to its periphery to act as a fan, while a pump is dispensed with, the water circulation being on the thermo-siphon principle. Ignition is by the Bosch high-tension magneto with fixed sparking point, the control being confined to a throttle lever on the steering wheel and a pedal accelerator. Lubrication is provided for by a pressure operated oiler mounted on the dash. The complete motor and clutch, which is of the three-disk type using cork inserts, is a simple

and compact unit, mounted on a three-point suspension to relieve it of any stress that would otherwise be imposed by any bending of the frame.

Drive is by propeller shaft, the gearset, differential, and bevel gears all being centered in the same housing which serves to enclose the live rear axle. The brakes are unusually powerful and are placed in drums on the rear wheels. Suspension takes the form of full elliptic springs in the rear and semi-elliptic springs forward. The steering gear is of the worm-and-sector type with easy provision for adjustment to take up wear, as is the case with every other part of

Fig. 27. Alco 4-Cylinder, 16-H. P. Taxicab.

the mechanism that is apt to develop looseness, while the complete units may be readily dismounted in a short time and replaced. The wheel base is 103 inches, wheels 32 inches in diameter, and tires 4 inches all round. Eight gallons of water are carried in the radiator, one gallon of lubricant in the pressure oiler, and 14 gallons of fuel, the economy of these cars being demonstrated by the fact that one of them covered 22.7 miles on a gallon of gasoline in the economy test held under the auspices of the Automobile Club of America in 1909.

For a number of reasons, the principal one of which has doubtless been the system of compensation, taxicab drivers have had a strong incentive to speed their cars and much of the damage suffered by taxicabs in service has risen from this cause. The designer of the Alco taxicabs, Fig. 27, has accordingly specified a maximum speed of 800 r. p. m. for the four-cylinder motor which forms the power plant of these cabs. At this speed, it develops 16 horse-power, which is ample for the purpose, and has the further advantage of not permitting the cab itself to be driven at a speed exceeding 20 miles an

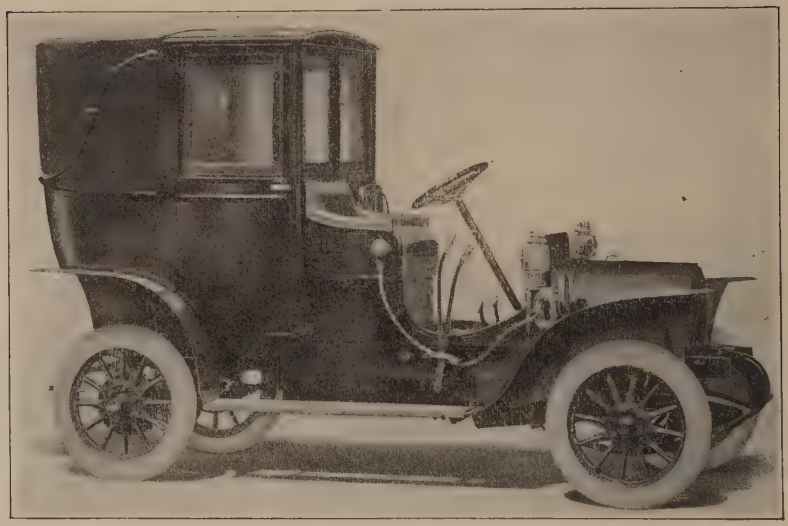


Fig. 28. Franklin 18-H. P. Taxicab

hour. This is the same motor that is employed on the Alco 3-ton truck, but in the latter case it is speeded higher and develops 24 horse-power. In both cases, the motor speed is automatically controlled by a throttling governor that cannot be tampered with by the driver. A Bosch high-tension magento is employed for the ignition, while lubrication is by splash, the supply being constantly replenished by a force-feed oiler. A sliding gear transmission of the selective type provides three forward speeds and reverse, final drive being by propeller shaft to a live rear axle of special design for cab work. Semi-elliptic springs are used forward and a three-member platform suspension in the rear. The wheel base is 104 inches, gauge

55 inches, while the tire equipment consists of 32-inch by 4-inch pneumatics all round. The weight of the complete car is 3,100 pounds.

The Franklin taxicab, shown in Fig. 28, has as its motive power a four-cylinder, $3\frac{3}{8}$-inch by 4-inch motor, rated at 18 horse-power, and cooled by a flywheel suction fan, as described in connection with the light trucks of the same make. In fact, the chassis is practically the same throughout, its dimensions being modified to suit the changed conditions of service. The ratio of gear reduction on the

Fig. 29. Altas 2-Cycle Taxicab.

direct drive is raised to 4.5 to 1 which gives the car speeds in excess of 20 miles an hour. All on, the weight is but 2,250 pounds, so that the tire equipment of 30-inch by 4-inch quick detachable pneumatics, front and rear, is ample.

The standardization of a chassis and power equipment for various forms of light to medium commercial service as shown by the American and Franklin trucks and taxicabs, is also to be found in the Atlas taxicab shown in Fig. 29. This is fitted with the same two-cylinder, 20-horse-power, two-cycle engine as that described in connection with the Altas delivery wagons. Owing to the extreme shortness of the motor, only a small hood is required and ample space is

allowed for the driver without the necessity of increasing the wheel base to accommodate a good sized landaulet body. Three-quarter elliptic springs are employed for the suspension in the rear, this, apart from the difference in dimensions and the fitting of pneumatic tires, constituting the only change of importance between the specifications of the cab and the delivery wagon. As shown in the illustrations of both the Franklin and Atlas taxicabs, it is customary to fit these vehicles with an individual driver's seat, the latter being on the left-hand side, in order to provide accommodation for a trunk or other baggage. A folding seat gives accommodation for an extra passenger when the space is not utilized for baggage.

GASOLINE DELIVERY WAGON

It will be found on a brief examination of the subject that this is a far more comprehensive heading than would appear at first sight, as it includes everything from the little three-wheeler up to the type known as the *light truck* but which is, in reality, also a delivery wagon with an open platform, or stake type of body. The range of carrying capacity is from one or two hundred pounds up to one ton, or slightly more, as many delivery wagons and light trucks are built with a load capacity of 2,500 pounds, or even 3,000 pounds.

Package Delivery Motorcycle. At the lower end of the range is to be found a hybrid type, consisting of all the elements of a motorcycle, minus the front wheel, for which is substituted a package-carrying box of light construction mounted on two wheels. This, of course, does not represent any closer approach to a true type of commercial vehicle than does the touring car chassis fitted with a second-hand landaulet body and a taximeter represent a practical and efficient taxicab. The motive power of this hybrid consists of a 2- to 4-horse-power, single-cylinder, air-cooled motor of the four-cycle type, driving the single rear wheel by a chain and having but one speed. As the entire machine weighs only a few hundred pounds, it is readily pushed backward, and so has no need of a reverse, while the power provided is ample and there is no necessity for a change-speed gear. It is started by pedaling and stopped simply by shutting off the ignition current, a coaster brake such as is used on bicycles and motorcycles being sufficiently powerful for all needs. The package body is of the lightest possible construction and its load-

carrying capacity is little more than nominal where weight is concerned. It is naturally intended merely for the quick delivery of comparatively small and very light packages, and in this rôle has proved successful to a limited extent. Low initial cost as well as the extremely economical expense of operation and maintenance are, of course, its chief advantages, and these naturally recommend it to the small shopkeeper. On the other hand, it has so many disadvantages that it is safe to say, its use is not at all apt to become general, even in this limited field. Both the rider and the mechanism are entirely exposed to the weather, and the machines, at least as built thus far, have not been designed with a view to commercial service.

Standard Delivery Requirements. Before taking up a description of the different examples of gasoline delivery wagons as an illustration of the various angles from which solutions of the problem presented by this highly important branch of commercial service have been attempted, it may be well to briefly summarize some of the principal requirements of the problem itself. They are exactly those which have been dwelt upon as being essential to the successful taxicab. The object to be attained is the same—a vehicle of the most reliable, efficient, and economical type and so simple as to be readily operated by an unskilled driver, the only difference really being in the nature of the load to be carried.

Simplicity of Design. This naturally involves the designing of the power plant and the drive as independent units, and more particularly the former, in order that the entire vehicle may not be placed out of commission, simply through some minor defection, which, though of relatively small importance, involves considerable delay in its repair. All functions of the motor must be as nearly automatic as it is possible to make them, little or nothing in the way of adjustments being left to the discretion of the driver. Ease and simplicity of operation must characterize the clutch and the gear-set, and every part must be of as durable construction as is possible to make it. In fact, the design and construction must be such that the driver's duties are confined almost wholly to starting, stopping, and steering, the vehicle running all day without further need of attention to any of its adjustments than can be given by the skilled attendants at the station before starting out. The ignition system is accordingly self-contained and independent, operating with a fixed

point of firing, and may only be retarded for starting; lubrication is entirely automatic and a pump is generally dispensed with, the circulation of the cooling water being on the thermo-siphon principle with an ample volume of water to secure adequate cooling under the most severe conditions. Simplicity has been attained in high degree by the adoption of a planetary type of gear set for the transmission, and this form, while slightly less efficient as compared with the sliding type, has proven very successful in the hands of unskilled drivers, as it cannot be abused. So far as the remainder of the chassis is concerned, solidity of construction within necessarily defined limits of weight, is naturally the chief characteristic, as very liberal provision for durability is imperative in view of the racking stresses imposed by heavy loads being carried on solid tires over rough pavements at high speeds, as compared with the horse-drawn vehicle.

Load Efficiency. While dealing with the question of weight, it may be well to point out the fallacies that have obtained on this point in the past, as this item alone has been directly responsible for the failure of many of the early attempts. The majority of the types were entirely too light for the service for which they were designed and simply went to pieces under the pounding. In the attempt to gain the highest possible load efficiency, and this sometimes actually exceeded 100 per cent, all other considerations were overlooked, with the inevitable result. That this is not something belonging entirely to the erroneous practice of an already forgotten past, is strikingly evidenced by the fact that the writer overheard the general manager of one of the largest motor-building companies in the country, seriously discussing the design of a delivery wagon to carry a load of 1,000 pounds on a weight of 1,000 pounds. The discussion took place within the past year. The vehicle was to be equipped with a four-cylinder, four-cycle, vertical motor of the high-speed type, capable of delivering 16 to 20 porse-hower, while the vehicle itself was to have a speed of 20 miles to 22 miles per hour on the level. It was proposed to turn out a large number of these vehicles for milk-delivery service, the assumption being that as this would confine them to city streets, the going would always be smooth and practically level.

On paper, the design appeared to be practical, but had these delivery wagons actually been built as proposed, they would have added but another failure to the long line that had preceded them

from the same cause, except that it would have been more widespreading in its effects owing to the great number it was contemplated constructing. No great amount of engineering skill is necessary to perceive their shortcomings. Carrying a load of 1,000 pounds on a total vehicle weight of 1,000 pounds, means an efficiency of 100 per cent, and as there is usually a tendency to over- rather than under-load vehicles in service, this would be still further increased. It is axiomatic in engineering that any such close approach to perfection is not consistent with durability. In other words, it is not practical to attempt to achieve such a high percentage of efficiency, where the limitation of total weight is so small. For instance, it is not difficult to construct a truck weighing two tons, that will be capable of transporting a load of two tons, but where the former limit is fixed at half a ton, it is an entirely different matter.

Furthermore, it is a gross fallacy to proceed on the assumption that a vehicle intended for strictly urban service may be built much lighter owing to the smoothness of the pavement. While asphalted or wood-block paved streets are now in the majority in large cities, they are not all smooth by any means. Holes, car tracks, and protuberances caused by the excavations for pipes and the extremely careless relaying of the pavement at such places, give rise to obstructions that are quite as serious in the stresses they impose on the vehicle, as any to be found on suburban or country roads adapted to the use of the commercial vehicle. A load-carrying efficiency of $66\frac{2}{3}$ per cent would approximately represent the maximum practically obtainable with such a light vehicle. In other words, the vehicle to have a useful load capacity of 1,000 pounds, should weigh at least 1,500 pounds, and 1,600 to 1,800 pounds would be more consistent with the high degree of reliability and freedom from breakdown that are so essential in any commercial service. As the size of the vehicle increased, these limits would naturally approach one another more and more closely, until, as already stated, an efficiency of 100 per cent, or very close to it, would be reached in the 2-ton truck and above, as will be noted by some of the weights given later.

As weight increases, speed for the same power must naturally decrease proportionately, so that while the same high-speed type of four-cylinder, vertical motor that has become standard on the pleasure car is frequently to be met with in commercial truck design—in fact,

manufacturers of pleasure and commercial chassis often use the identical motor on both—the ratio of speed change is much greater. In pleasure car practice, it is customary to make the gear ratio on direct drive, or high speed, $3\frac{1}{2}$ to 1 for touring and enclosed cars, and 3 or $2\frac{1}{2}$ to 1 on high-powered runabouts, *i. e.*, when driving direct, the motor makes $3\frac{1}{2}$ revolutions for every turn of the road wheels. As the normal speed of the motor ranges from 1,000 to 1,500 r. p. m., or even higher in the case of some of the smaller powers, this gives a speed range of from 4 to more than 60 miles an hour. On the first and second speeds, the gear ratio is usually about 5 and $7\frac{1}{2}$ or 8 to 1, the reverse often being the same as the first speed, and in some cases a little slower, say $8\frac{1}{2}$ or 9 to 1.

When it is considered that on a weight of 3,000 to 3,600 pounds, the seven-passenger touring car seldom carries a load of much more than 1,000 pounds—seven passengers, average 150 pounds = 1,050 pounds—it will be apparent that its load efficiency does not exceed $33\frac{1}{3}$ per cent and is usually much less. Furthermore, owing to inability to run, except at short intervals, at anything like an efficient motor speed, the fuel consumption for the load carried, is very high. As load-carrying efficiency and economy in operation are two very important features of commercial car design, it is evident that to realize them, pleasure car practice must be radically departed from.

High Efficiency on Low Speed. Owing to the manner in which the internal combustion motor develops its energy—*i. e.*, by means of intermittent impulses or blows of high unit value, which must be absorbed and "smoothed out" so to speak, by the heavy balance wheel, in order to be available—its torque, or pulling power, is very low at low-turning speeds. A motor designed to have an output of 30 horse-power at a speed of 1,200 r. p. m., will not deliver 15 horse-power at 600 r. p. m. In fact, the efficiency falls off so rapidly with a decrease in the speed, that a drop of 50 per cent in the latter means a decrease of 75 per cent or more in the power developed, so that at 600 r. p. m., the 30-horse-power motor would probably have an output not exceeding 8 to 10 horse-power. Ability to develop the maximum amount of power over the greatest speed range is known as the *flexibility* of the motor, and the internal combustion motor has been vastly improved in this respect during the past decade. However, as this is an inherent disadvantage that cannot be entirely

overcome, provision for a change in the speed from the motor to the rear wheels must always be necessary, and it is essential that this be calculated so as to permit of the motor running as close to its normal speed as possible at all times, regardless of the speed at which the vehicle itself is traveling.

In view of the far greater discrepancy between the speed at which the motor must necessarily turn in order to be efficient, and the permissible maximum speeds of the vehicle as compared with the pleasure car, the problem of adapting the speed changes to the requirements is much more difficult. This is further complicated by the fact that the torque of a motor also falls off when its speed greatly exceeds normal. In other words, its efficiency drops when the motor is allowed to race, in almost the same proportion as it does when the motor is run below its normal speed. Commercial vehicle speeds must necessarily be low, not alone to permit of the transportation of heavy loads, but also in order that the car may be able to ascend grades when fully loaded, so that the gear ratio must be calculated to prevent racing on the first and second speeds, as otherwise the starting ability of the vehicle will be low, and it will be necessary to race the motor in hill climbing with consequent overheating. As racing the motor much beyond its normal speed also imposes great inertia stresses on all the moving parts, the importance of avoiding a ratio of gear change that will involve it on any of the speeds will be manifest. Improvements in motor design which have made it possible to reduce the normal speeds of motors ranging from 35 to 60 horse-power as low as 800 to 950 r. p. m. have done much to simplify this problem, so that the car with a motor specially designed for commercial vehicle work has an advantage over one using a touring car motor. This is especially true in the case of the heavier trucks in which the maximum permissible speed of travel seldom exceeds 10 miles to 12 miles per hour.

Pleasure-Car Design vs. Commercial. Consideration of the foregoing will throw considerable light on one of the chief differences between the pleasure car and the commercial vehicle of the gasoline-driven type. It will be apparent that instead of a gear ratio of $3\frac{1}{2}$ or 4 to 1, the highest available on the direct drive will form a close approach to the first speed of the pleasure car, or about 8 to 1, with a corresponding decrease for the starting and hill-climbing speeds,

bringing these as low as 22 to 27 turns of the motor for each revolution of the driving wheels, the actual ratio naturally varying with the size and type of vehicle, as controlled by the load to be transported.

Delivery wagons are accordingly designed with speeds of approximately 4 and 12 miles an hour on first and high, where provided with but two gear changes, and of 4, 8, and 15 to 18 miles, where three speeds are available. However, as the delivery wagon is usually designed to carry a comparatively light load, advantage is taken of this to employ a planetary type of change-speed gear. This type is greatly to be preferred on light vehicles in view of the unskilled class of drivers usually employed, as it is not subject to abuse as is the sliding gear type, but it does not lend itself to a three-speed gear as this involves excessive complication. While ordinarily employed on light delivery wagons, it has also been used very successfully on trucks as heavy as 10-ton capacity.

Types. *Brush.* As there is a wide diversity of types of delivery wagons, a study of their design and construction as exemplified by various makes will serve to give a clearer idea of the manner in which the different problems that arise have been met, than any generalization possibly could. At present, the first step above the motorcycle tri-wheeler with its maximum capacity of about 250 pounds, is the Brush 500-pound delivery wagon, Fig. 30, employed by the Federal government for mail carrying, in which it has proven very successful. The motive power of these small cars consists of a single-cylinder, vertical, high-speed motor rated at 7 horse-power. It is of the four-cycle type and water-cooled, and as is the case in pleasure car practice, the entire power-plant is carried forward under a bonnet, which makes it very accessible. Owing to the short wheel base of the car, the driver's seat is directly back of the bonnet—or where the dash would ordinarily be placed—necessitating the location of the steering gear right over the forward axle, as shown, the brake pedal being on the frame and directly back of the steering column. Instead of being centered directly on the chassis, the bonnet is slightly to the right, providing ample space for the driver's feet at the left, where the control is placed. Left-hand control, as it is termed, *i. e.*, the placing of the driver's seat and operating levers at the left instead of at the right, as has been almost universal heretofore, has numerous advantages for commercial work. As practically all

the driving is done in traffic, the practice is becoming more or less general on commercial cars, the taxicabs being the first to employ it to any extent, though one or two pleasure cars have been thus equipped for the past two or three years.

The transmission of the Brush consists of a two-speed planetary gear and a countershaft from which the drive to the rear wheels is taken by side chains, as shown. The suspension takes the form of four heavy helical springs, the action of which is controlled by means of a special form of shock absorber, which prevents the recoil of the

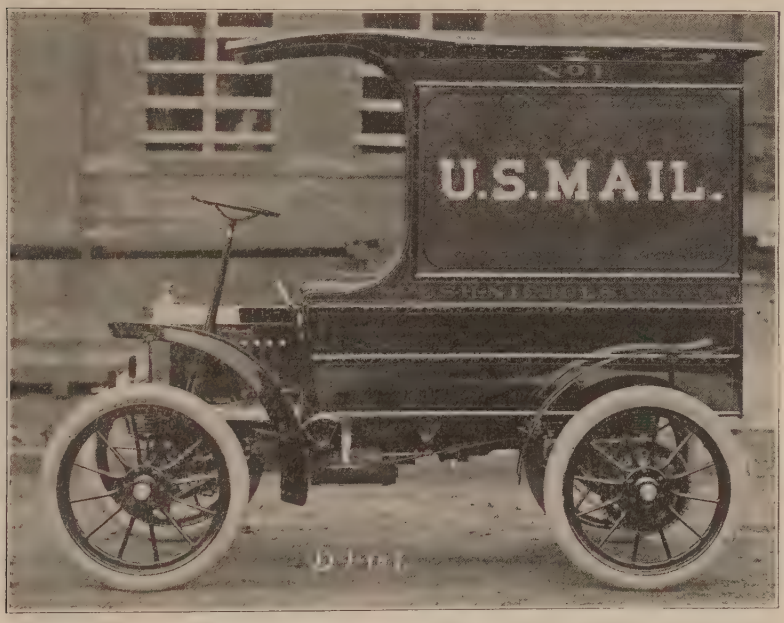


Fig. 30. Brush 500-Pound Delivery Wagon.

springs from setting up the continuous jouncing characteristic of this type of spring, and also serves to check the lateral swaying to which the body would otherwise be subject. One of these shock absorbers is placed at each spring. Both front and rear axle are of tubular construction. The total weight of the car is 950 pounds, and as it has a load-carrying capacity of 500 pounds, its efficiency exceeds 50 per cent, which is high for such a small vehicle.

Holsman. As the capacity of the usual horse-drawn delivery wagon seldom exceeds half a ton, there are naturally a great number

of power-driven vehicles for the same purpose that are rated with a carrying capacity of 1,000 pounds, though the majority of them are

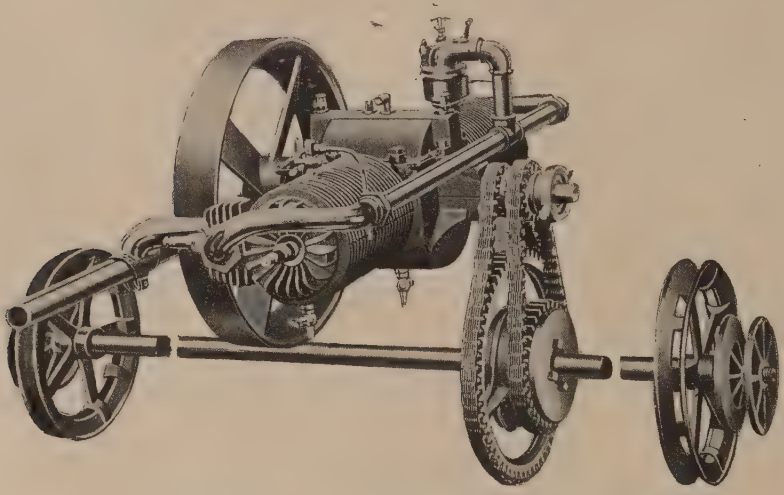


Fig. 31. Holsman 12-H. P., 2-Cylinder Engine and Transmission.

actually capable of transporting more than this—in some cases up to 1,500 pounds. A type that embodies many special features is to be found in the Holsman. This is equipped with a two-cylinder opposed, horizontal, air-cooled engine, rated at 12 horse-power.

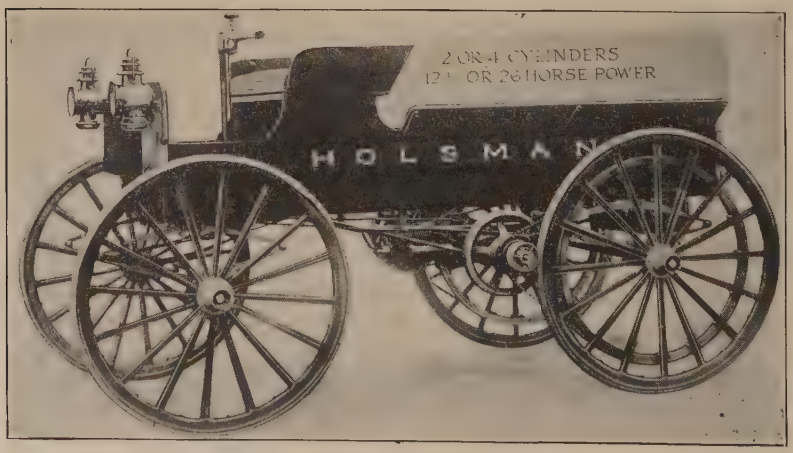


Fig. 32. Holsman High-Wheeled Motor Wagon for Country Use.

It is of the four-cycle type and drives by means of silent chains to a countershaft, as shown in Fig. 31. From the latter, the final drive to the rear wheels is taken by means of steel and manila cables running in grooved pulleys, this construction being illustrated in the complete view of the vehicle, Fig. 32. The suspension consists of full elliptic springs at all four points. High wheels and solid axles are employed, in fact, the whole construction is a close approach to the "horseless" type that was first evolved in automobile design. The control is centered on a vertical column at the right, steering being accomplished by means of a hand lever.

Black. A type that has been evolved directly from the first attempts at pleasure-car design in this country, is illustrated in the

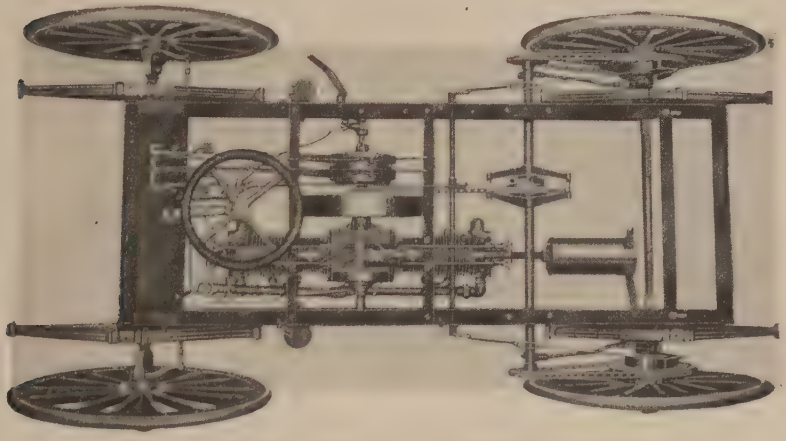


Fig. 33. Chassis of Black 12-H. P., Light Delivery Wagon.

plan view of the chassis of the Black 12-horse-power, light delivery wagon, Fig. 33. Except for the employment of an air-cooled motor, this is typical of the arrangement used on the majority of early two-cylinder cars. The engine is placed under the body and parallel with the frame, the planetary gearset being carried directly on an extension of the crank shaft. From the latter, the drive is by means of a single chain to a countershaft and double chains to the rear wheels. The frame is of angle iron, securely braced, and full elliptic springs and solid axles are employed, most of such parts, wheels included, coming directly from the stock of the wagon parts manufacturer. The construction of the motor is shown in Fig. 34, and except for

detailed changes, this is, in general, typical of the majority of two-cylinder opposed motors of the horizontal type, whether air or water-cooled.

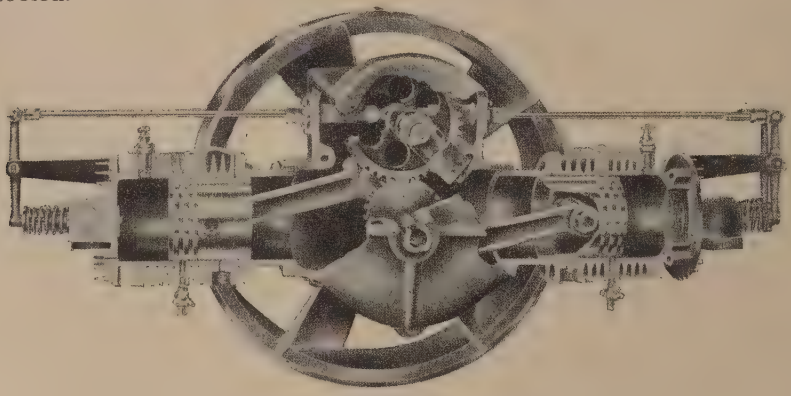


Fig. 34. Black Double-Opposed 12-H. P., to 18-H. P., Air-Cooled Engine.

Reliable-Dayton. An improvement on the foregoing, in that the working parts are much more accessible, is shown in the plan view of the chassis of the Reliable-Dayton delivery wagon, Fig. 35. The motor is placed transversely at the forward end of the pressed steel

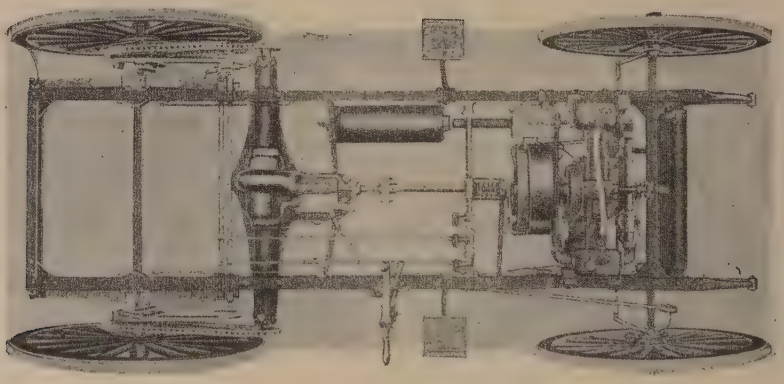


Fig. 35. Chassis of Reliable-Dayton 750-Pound Wagon.

frame. It is water-cooled and is rated at 20 horse-power. The radiator, of the horizontal tubular type, is hung below the frame, the power-plant being protected by a sloping bonnet, which, when raised, permits of direct access to all parts of the engine. A band

Fig. 36. Cartercar Delivery Wagon.

so that the transmission wheel may be moved across its entire face, both the speed and the direction of rotation depending upon the point at which the wheel makes contact with the disk, the center of the disk naturally representing a neutral point. The periphery of the wheel is equipped with a special friction material, which may be replaced at a nominal expense when worn. A transmission of this type provides a wide range of speeds, both forward and reverse, with a very gradual and easy increase or decrease, it being possible to go into reverse while the car is still moving forward, though this is also a feature of the planetary type of change-speed gear. The view of the power-plant and transmission also illustrates the construction of the internal expanding brakes and the rear axle.

In operation, all speed changes are obtained by means of the single hand lever which serves to shift the wheel across the disk. The car is started or stopped by depressing or releasing a pedal on the footboard.

Van Dyke. The Van Dyke 1,000-pound delivery wagon represents another instance in which friction transmission is employed, but in a totally different manner. The two-cylinder, horizontal, opposed motor comprising the power-plant, is placed at the left-hand side of the chassis, forward, and is carried parallel with the frame on two transverse members. These cross pieces also serve to carry two bearings which support a horizontal shaft on which the sliding friction wheel is mounted. The flywheel of the motor also serves as the friction disk. Drive is by propeller shaft to a live type of rear axle, which also embodies the differential. As the car is intended for low speeds, the gear ratio of the drive at the rear axle is 6 to 1, which, with the speed changes available in the friction transmission, permits of driving it at anything from half a mile an hour up to the maximum, which will probably not exceed 15 miles an hour.

Randolph and Lambert. The Randolph and Lambert vehicles also employ a friction type of transmission designed on the same general lines. That of the Randolph 1,500-pound delivery wagon is illustrated in Fig. 38, the method of sliding the transmitting wheel on the splines of the countershaft, as well as the manner of fitting it with a special friction facing, both being plainly evident. The disk, driven by the motor, which in this case is also of the twin-cylinder, horizontal type placed transversely across the forward end of the

chassis, is also apparent. Final drive is by double side chains, according to standard practice on such vehicles. The friction type of transmission on the delivery wagons of this size has lately been discontinued, a gear drive being substituted. The same makers build a slightly larger vehicle with 2,000-pound capacity in either the friction or gear drive. The friction transmission does not lend

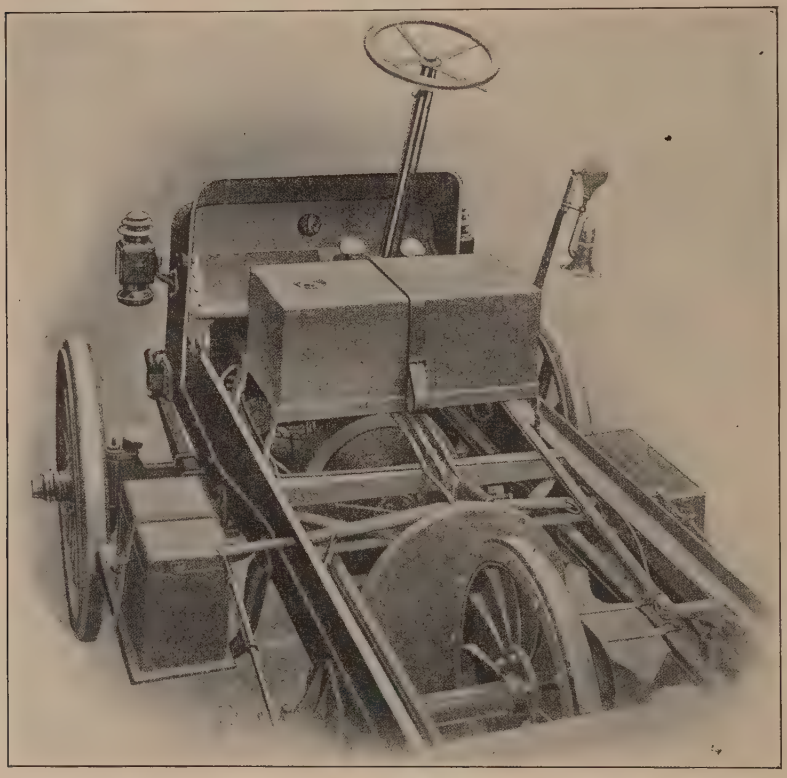


Fig. 38. Randolph Delivery Chassis Showing Friction Drive.

itself to heavier vehicles and has seldom been employed on anything much larger than a 1-ton or 1½-ton wagon.

Friction Drive. The friction type of transmission is not generally regarded with favor by engineers, as is shown by the comparatively small number of vehicles in which it is employed. As already mentioned, this type seldom exceeds one ton in capacity, but in this rôle the friction transmission appears to bear out to a very large extent the promise of its very favorable theory. The area of actual contact

between the disk and the power transmitting wheel is little more than a short line, and it would accordingly not seem to be capable of transmitting a great deal of power—particularly the effort due to starting a load on a grade or out of a mud hole—but the fact that the Carter-car vehicles have shown themselves capable of ascending grades as steep as 50 per cent, and of being stopped and restarted on such a terrific incline, would appear to dispose of this effectively. In actual service, grades as bad as 20 per cent are very rarely encountered, as a 15 per cent grade represents an exceedingly steep incline. The success of the friction-driven cars now on the market makes it apparent that this type is to be reckoned with as a factor, its low cost and absolute simplicity making it of great importance where the unskilled driver is concerned.

Most of the vehicles thus far described, with such exceptions as the Randolph and possibly one or two others, are really nothing more than pleasure car chassis with a delivery body mounted on them, but as they have been designed with a view to simplicity of construction and economy of operation, they have proven effective in both rôles. Doubtless the day is not far distant, when, with the aid of readily interchangeable bodies, the small merchant will find it profitable to use his car for both business and pleasure, by simply substituting a touring body in the evening or on Sundays and holidays. This was proposed in England several years ago, and a system of interchangeable bodies, permitting of a change from one to the other in half an hour or less, was devised to make it feasible. There appears to be no reason why the use of the machine in this double capacity should not be found entirely practical.

Special Types. For the hard and unremitting service called for by department stores and other large business houses, it is naturally quite as much of an advantage to have a vehicle specially designed for delivery purposes, as is the case with the heavier trucks. Such cars are run constantly and are, for a large part of the time, loaded to their rated capacity. It is nothing unusual for them to average 10 to 14 hours a day, practically every working day of the year that they are in use, and service of this nature does not allow for a great deal more idle time than is actually necessary for the daily washing and overhauling required to keep them up to a high standard of efficiency.

Autocar. The Autocar open-body delivery wagon, Fig. 39, affords an excellent example of a vehicle designed especially for the most severe business conditions. The motor is of the two-cylinder, horizontal, opposed, four-cycle type, the cylinder dimensions being $4\frac{3}{4}$-inch bore by $4\frac{1}{2}$-inch stroke, and it is rated at 18 horse-power, according to the standard set by the Association of Licensed Automobile Manufacturers (A. L. A. M.) controlling the Selden patent. The crank shaft is mounted on imported annular ball bearings which not only add greatly to the efficiency of the motor as a whole, but do away with the attention necessary to adjust plain bearings. This construction, which is far more expensive than plain bearings, also

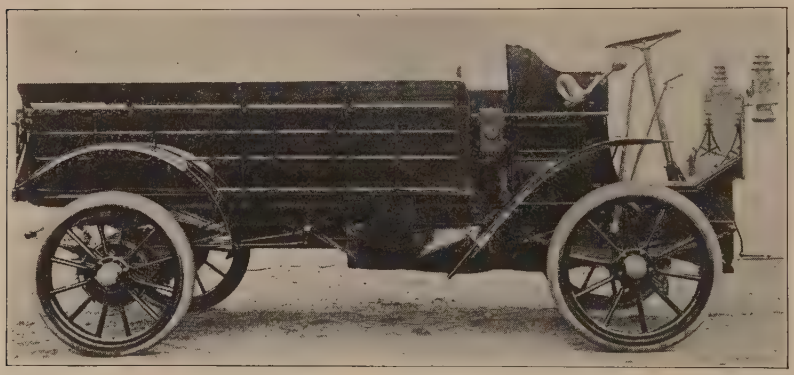


Fig. 39. Autocar Open Body Delivery Wagon.

reduces the number of parts which are subject to damage should the driver neglect to provide sufficient oil, the lubrication system otherwise being entirely automatic. Two flywheels are carried on the crank shaft, the forward one having its blades cast staggered so as to set up a strong current of air, thus eliminating the necessity of a belt- or gear-driven fan, while the rear flywheel carries the clutch. The importance of providing ample weight in the balance wheel is something to which insufficient attention has been devoted in the past, its influence upon the starting ability and smooth-running qualities of the vehicle being extremely marked, especially where a two-cylinder motor is employed. Both flywheels on the Autocar motor are counterweighted, and this, supplemented by a careful balance of all the reciprocating parts, makes an extremely smooth

and quiet-running motor with unusual starting and grade climbing ability for its size.

The crank case is split horizontally into two sections, the lower half carrying the cylinders, crank shaft, cam shaft, and water pump, while the upper half carries the push rod guides, the magneto, the oiler, and a gear for driving the water pump. The magneto and oiler are both driven through bevel gears and short shafts, reducing the possibility of failure in these two highly important essentials—ignition and lubrication—to a minimum. This upper section of the crank case is readily removable, carrying its parts with it and thus giving access to the crank-pin bearings without the necessity of dismantling the motor. A Bosch magneto is employed with a fixed firing point, thus taking this element of control out of the hands of the driver. Lubrication is by a force-feed oiler delivering oil through a sight feed to the crank case, from which the pistons, crank pins, and main bearings are lubricated by splash. Both the magneto and the lubricator are simply attached to the crank case by wing nuts so as to be removable without the aid of tools. A hydraulic speed regulator connected in the circulation of the cooling water, controls a throttle placed in the intake manifold between the carbureter and the cylinders, limiting the speed of the motor to 1,400 r. p. m. and that of the vehicle to 18 miles to 20 miles per hour.

A patented floating ring clutch that has been developed on the same make of pleasure cars and used for a number of years, constitutes the first step in the transmission. It consists of a bronze floating ring, lined with cork inserts on its inner face, and mounted on four keys on the inside of the rim of the rear flywheel, thus rotating with the latter. Two cast-iron rings, adapted to clamp the bronze ring when the clutch is engaged, are mounted on the clutch shaft, which extends into the transmission case. Engagement is accomplished by a sliding trunnion and four toggle links, the motion of which is checked by a dashpot and plunger. This insures gradual automatic action, entirely free from jerk regardless of the care exercised by the driver. The addition of small springs to the floating ring eliminates all noise whether the clutch be engaged or not, while the arrangement is such that adjustments can be easily and readily made.

The transmission housing is all one piece, except its cover plate, and it has been so designed that all the shafts and gears may be

removed without disturbing the housing itself. The shafts are large and are carried on adjustable roller-bearings, while the gears have broad faces and heavy teeth. Three speeds forward and one reverse

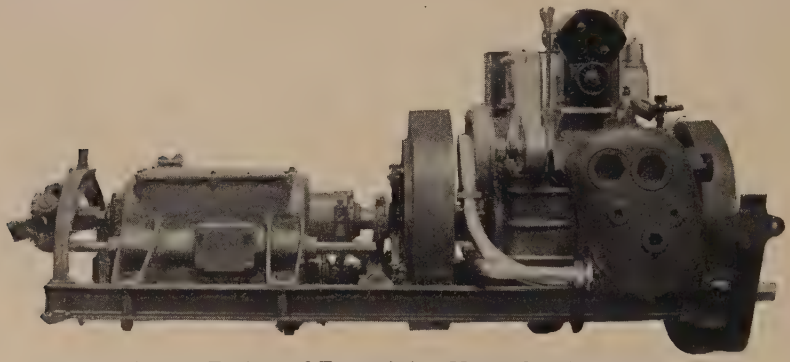


Fig. 40. Autocar Engine and Transmissiom Mounted on Separate Sub-Frame.

are provided, lubrication being obtained by covering the shafts and gears with a bath of semi-fluid oil.

Both front and rear axles have been designed especially to meet

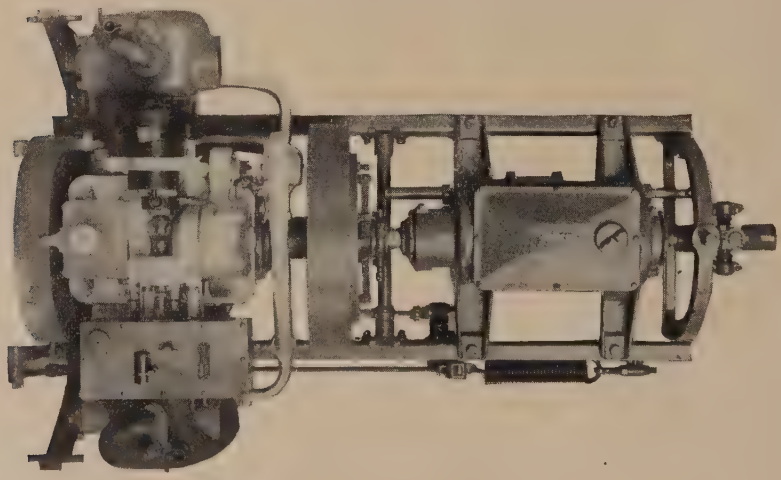


Fig. 41. Autocar Engine and Transmission—Plan View.

the requirements of the heavy service imposed upon them in carrying the load on solid rubber tires. The front axle is of the tubular type, with extra heavy yokes for the steering spindles, which are made integral with the spring saddles. Adjustable roller-bearings are

employed in the wheel hubs. The rear axle is of the full floating type with a double gear reduction. A bevel pinion at the end of the propeller shaft meshes with a large bevel gear on a short transverse shaft, from which the drive is transmitted to the differential case by means of a pair of substantial spur gears. The bevel pinion shaft and the jack shaft both run on adjustable roller bearings.

One of the chief features of advantage of the Autocar delivery wagon is the mounting of the complete motor and transmission, barring the rear axle, on an independent subframe, as shown in Fig.

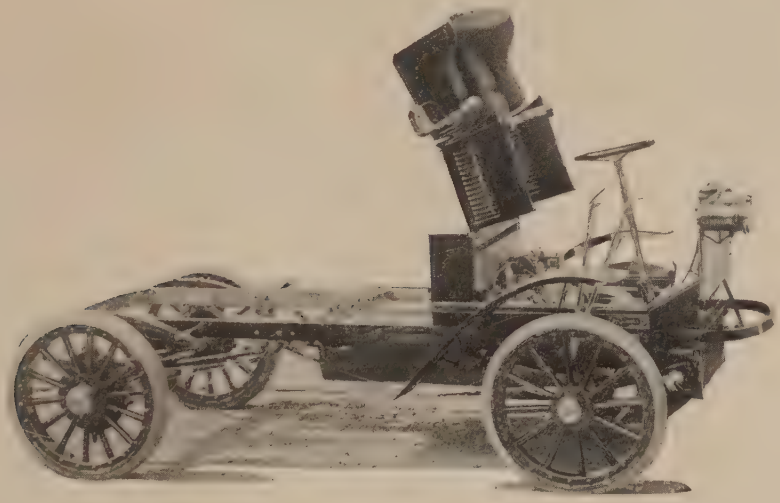


Fig. 42. Autocar Complete Chassis.

40 and Fig. 41. In the illustration of the complete chassis, Fig. 42, every part of the power plant is seen to be accessible by lifting the bonnet, while the complete unit, as shown separately, may be removed from the chassis and replaced by another. The plan view of the chassis, Fig. 43, shows the relative location of all the essential parts, including the gasoline tank which is placed transversely on the main frame directly under the driver's seat. The frame is of pressed steel, perfectly rectangular and heavily reinforced. Two sets of brakes act on drums attached to the driving wheels, while the suspension consists of double-elliptic springs in the rear and semi-elliptic springs placed forward directly under the motor.

Grabowsky. The Grabowsky power wagon is another specially designed type having similarly advantageous features of accessibility and interchangeability, the entire power-plant and transmission being

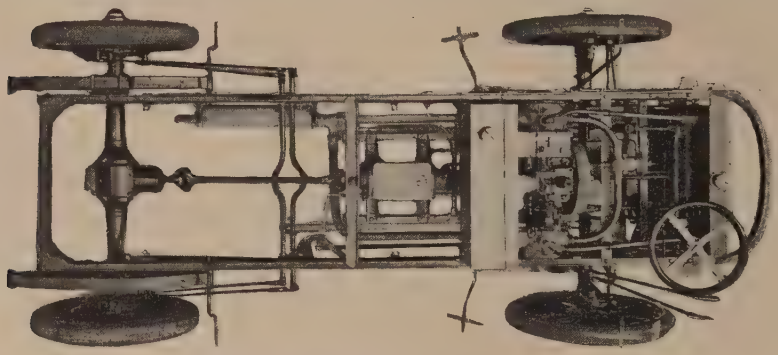


Fig. 43. Autocar Complete Chassis—Plan View.

an independent unit which is designed to slide on rails on the chassis frame, so as to be readily installed or removed. The simplicity of

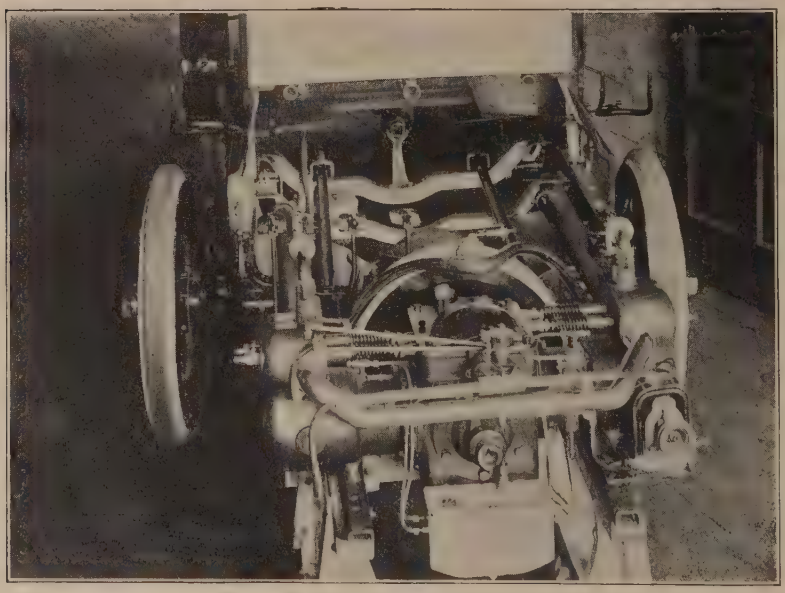


Fig. 44. Grabowsky Power Wagon, Showing Sliding Mounting for Power Plant.

this operation may be judged from the illustration, Fig. 44, which clearly shows the channel members upon which the motor and trans-

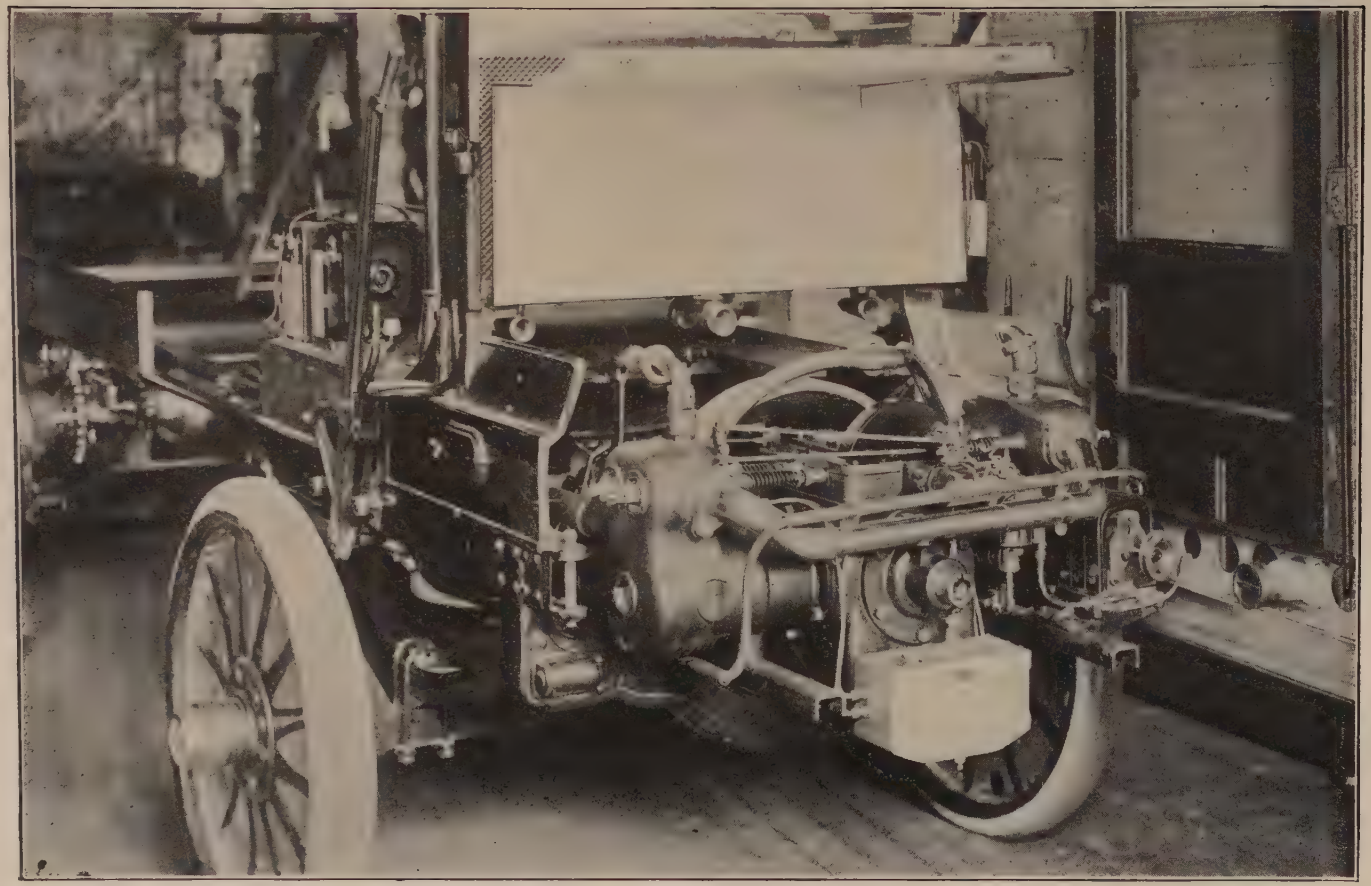


Fig. 45. Grabowsky Power Wagon with Interchangeable Power Plant—Side View.

mission gear are mounted, as well as the rails of similar section placed in an inverted position on the chassis, on which they are designed to slide. By means of the horse mounted on casters and shown in the foreground, the motor and its accompanying essentials may be slid off the chassis and replaced by another in a very short time. This is a great advantage to any delivery system employing a number of vehicles, as with an extra equipment of one complete power plant for every eight or ten cars in service, it is seldom, if ever, necessary to retire a machine from service to make repairs to the motor or transmission, as the extra unit may be temporarily installed in any one of

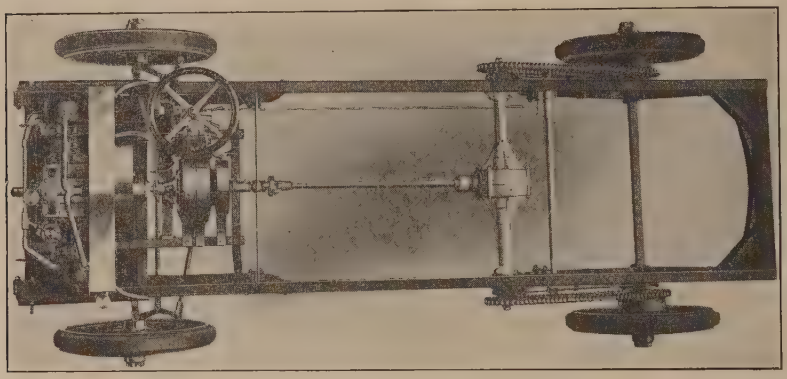


Fig. 46. Grabowsky Chassis Showing Simple Construction.

the cars needing attention of this nature. This is on the same principle as the keeping of three horses to insure the steady service of a single two-horse wagon, six for two team wagons, and so on; except that the percentage of extra motive power necessary in the case of horse-drawn vehicles is much greater than with power wagons. The Grabowsky car shown is much heavier than the delivery types previously illustrated—in fact, it is a truck chassis, but is shown in this connection following the Autocar as a further example of a special design involving much the same principles.

Fig. 45 serves to illustrate the ready accessibility of the various essentials of the motor by merely lifting the short hood. It may be noticed in this case that the radiator is carried above the motor. The force-feed lubricator will be seen forward just under the end of the crank shaft, while the direct-current generator for

supplying the ignition current is bolted to the right-hand rail of the sliding motor sopport; the ignition timer is mounted vertically, directly over the crank shaft. The valves and their operating mechanism, the spark plugs, carbureter, and electrical and water connections are all within easy reach, most of them being mounted directly on top of the motor. Fig. 46 illustrates the great simplicity of the chassis as a whole. The drive from the planetary gearset, which is shown in part section in Fig. 47, is by shaft to the differential, mounted at the center of the countershaft near the rear. From this, the drive to the rear wheels is taken by side chains in the conventional

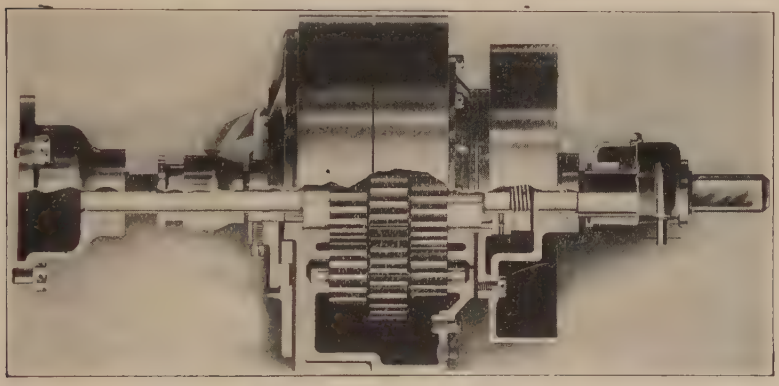


Fig. 47. Planetary Gearset Shown in Part Section.

manner. Internal expanding brakes are designed to act upon the drums which also carry the driving sprockets.

Rapid. The Rapid cars, while specially designed in many forms for commercial service, and in which they have proven unusually successful, are characterized more by features of design that have been conventionalized in the two-cylinder pleasure car. Like the Autocar and the Grabowsky, the Rapid one-ton chassis is equipped with a two-cylinder motor of the same general type, the cylinders of which measure 5 inch by 5 inch, giving it a rating of 24 horse-power. It is placed parallel with the frame and under the body, the crank shaft carrying a two-speed planetary gearset through which the power is transmitted by a single chain drive to a countershaft, from which it is taken by means of side chains to the rear wheels in the usual way. While placed under the body, the motor is readily

accessible from the side of the car, due to the somewhat greater height of the frame. The radiator is carried forward and serves as a dash, while the suspension consists of a half-platform unit composed of three semi-elliptic springs in the rear, and two straight semi-elliptic springs forward. Solid axles of $1\frac{3}{4}$-inch square section are employed, and it will be noted from this and other details of the construction that the vehicle is unusually subtsantial for its size so that its rating of one-ton capacity is merely nominal. The wheels run on Timken roller bearings and may be either of the usual artillery type or what

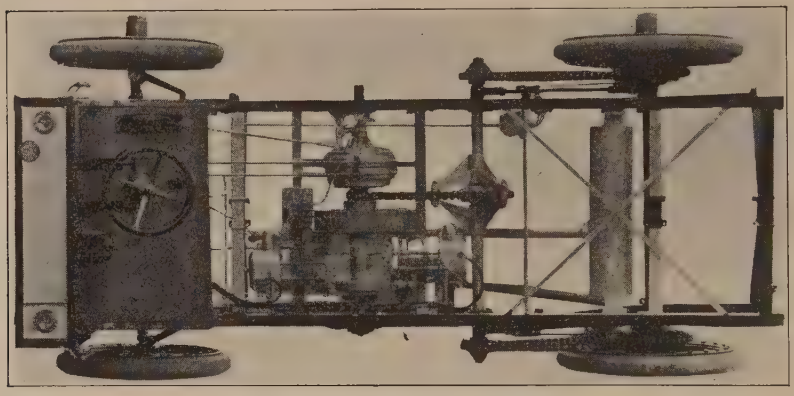


Fig. 48. Chassis of Rapid Delivery Wagon.

is known as an *indestructible* wheel, made of heavy, stamped sheet steel, which not only has the advantage of great strength but is easier to keep clean than the ordinary spoked type. Internal-expanding hub brakes are employed on the rear wheels and are operated by a hand lever, and as is usual with a planetary gearset, the reverse may be employed as a transmission brake. The wheels are 32 inches in diameter and are fitted with $3\frac{1}{2}$-inch solid-rubber, endless tires. By increasing the dimensions of the chassis throughout, and equipping it with a $5\frac{1}{4}$-inch by 5-inch motor, rated at 30 horse-power, it is listed as a $1\frac{1}{2}$-ton to 2-ton car with a number of different types of bodies. One of the Rapid cars has the distinction of being the only commercial vehicle to have climbed to the summit of Pike's Peak. A chassis of the one-ton Rapid delivery wagon is shown in Fig. 48.

Types with Two-Cycle Motor. Owing to its great simplicity and lack of small parts, the two-cycle type of motor would certainly

appear to hold great promise for the commercial field. It is far cheaper to build than the four-cycle type, as, with the exception of the crank shaft, connecting rods, and bearings, a two-cycle motor is composed wholly of iron castings. While not quite as economical in operation as the four-cycle where fuel consumption is concerned, the difference is hardly of sufficient moment to have an important bearing, and may be compensated for, to a large extent, by the lesser number of cylinders required, owing to the more frequent impulses. Its entire absence of valves and the numerous small parts which their operation involves makes it a particularly advantageous type to place in the hands of the ordinary driver, as, outside of the carbureter and ignition, there is absolutely nothing in the way of adjustments that the driver can tinker with. Owing to the fact that the four-cycle motor had none of the short-comings of the two, the latter was never considered seriously in the early days and almost entire attention was devoted to the development of the former, and, except for the efforts of a few pioneers with the courage of their convictions, it has not had an opportunity to demonstrate of what it is capable, either in the commercial or the pleasure-car field.

There are a few makers building two-cycle commercial cars—the whole field, in fact, both pleasure and commercial, can be accounted for on the fingers of one hand. Consequently, the two-cycle motor is still in an unsettled state—it has not yet reached that stage in its progress where it can be regarded as having been placed on a standard basis, as practically every maker is building a motor with special features of his own and no two are exactly alike, while many differ radically. But the promise it holds of future development may be gauged from its performance for many years past in the marine field, as there are thousands of small two-cycle motors in use in dories, oyster boats, and fishing boats that are put to the hardest class of business service day after day and in all kinds of weather. The two-cycle motor is also employed on a very large and constantly increasing number of motor boats for pleasure use. While marine service demands the sturdiest of construction, the speed requirements are low, the ordinary two-cycle marine motor being designed to develop its power at a normal r. p. m. rate seldom exceeding 600 turns per minute This naturally involves a weight per horse-power that is prohibitive for automobile use, the usual

6- to 8-horse-power, two-cycle, marine motor weighing quite as much or more than a 30-horse-power, four-cycle, automobile type. The reason for this will be apparent upon a consideration of the reference to the flexibility of the motor and its power output as influenced by its speed, Page 56. Weight is naturally not as objectionable in a boat as on a vehicle which must transport itself and its load on rubber tires. No little difficulty was experienced at the outset in the attempt to improve the two-cycle motor by increasing its speed in order to cut down its weight per horse-power, and the action of the motors under experiment was so erratic and unsatisfactory, particularly where an increase in their power output at the higher speeds was concerned, that many of the investigators gave up the task and went back to the four-cycle type. It is almost beyond the power of the human mind to grasp the rapidity of the sequence with which the different functions take place in a four-cycle motor when running at speeds which were thought utterly impossible twenty years ago, but which are now common. When turning over at 1,800 r. p. m., as many small motors do, they are making 30 revolutions per second. This means that 120 distinct operations must be gone through every second, *i. e.*, drawing in of the charge, compressing, firing, and exhausting it. For the accomplishment of each, there is thus allowed exactly $\frac{1}{120}$ of a second. In fact, it has never quite been figured out how the various operations can follow one another so rapidly without conflicting—just how the burning gas of one charge can be so completely expelled as not to ignite the fresh gas of the charge following it. 1,800 r. p. m. is not an extreme speed by any means, as motors have been successfully operated at a rate as high as 2,200 r. p. m. or more, though the average automobile motor is not designed to run much above 1,500 r. p. m. and the tendency is naturally to lower this rather than to increase it.

When a two-cycle motor is running at 600 r. p. m., it is carrying out as many functions as the four-cycle motor running at double that speed, so that to design a two-cycle motor capable of a speed of 1,800 r. p. m. it is necessary to so arrange its intake and exhaust that the gases may be successfully transferred with the small time allowance of $\frac{1}{240}$ of a second. This explains why the first attempts were so disappointing, as the fresh charge was either fired by its predecessor before reaching the combustion chamber, or was so small as to be

productive of practically no power, this decreasing, instead of increasing, as the speed became greater. The investigations were continued, however, with the result that there are now several cars of this type that have been on the market for some time, while others are still being experimented with, and it is safe to say that the two-cycle motor will in the future become a factor of constantly increasing importance, particularly for commercial use.

Atlas. The extreme simplicity its employment makes possible is strikingly illustrated by the plan view of the Atlas delivery wagon shown in Fig. 49. As the two-cycle motor produces a power impulse for every turn of the crank shaft, instead of every other revolution, as in the four-cycle motor, it is natural to assume, that, given the

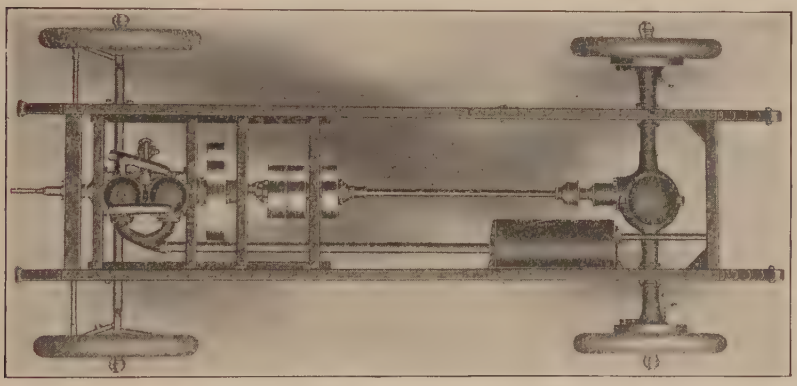


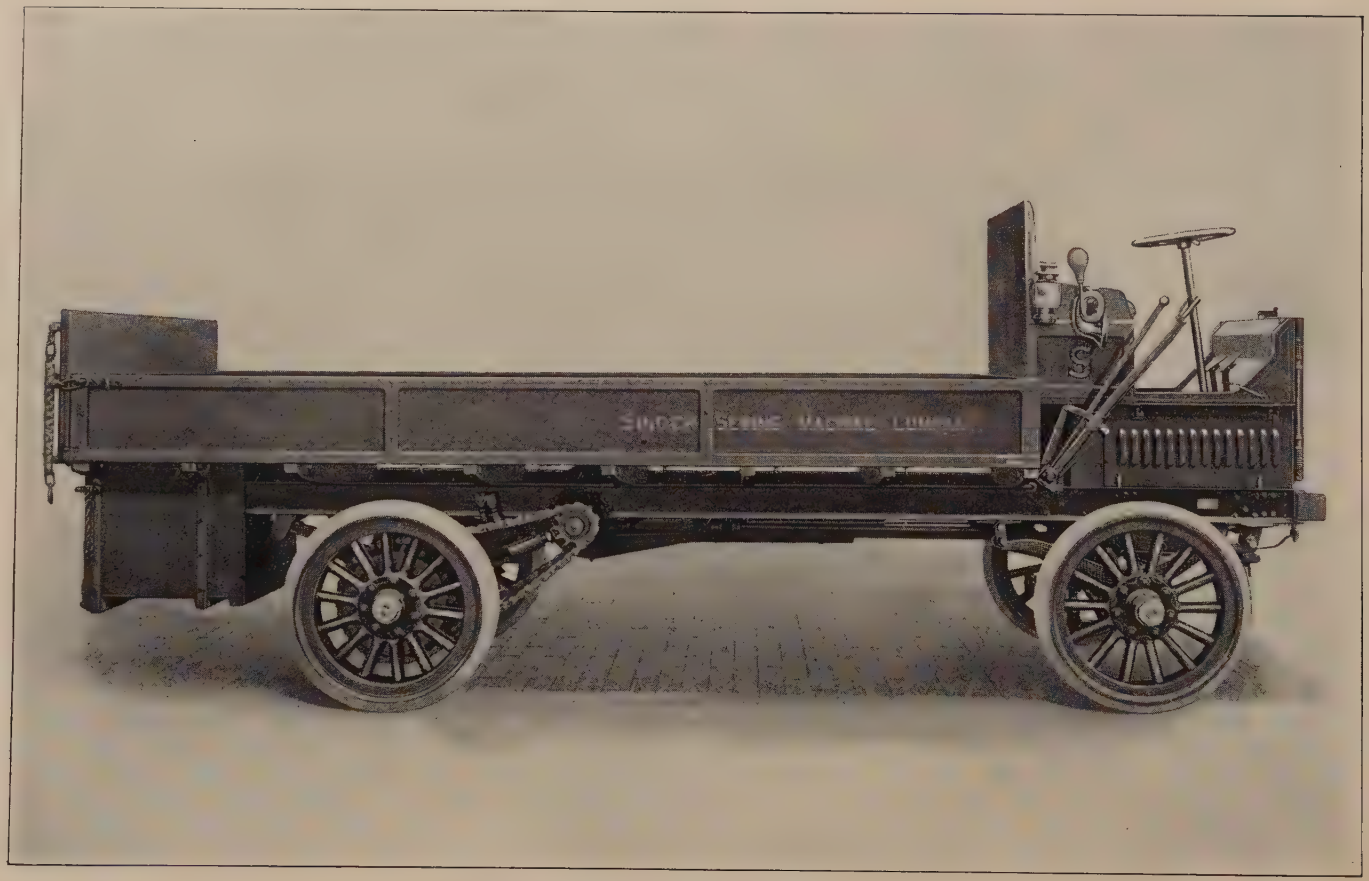
Fig. 49. Chassis of Atlas Delivery Wagon.

same size cylinders, the power output will be exactly double, or even better, and this is a claim generally put forth by the builders of two-cycle engines. It doubtless would be true were it possible to scavenge the cylinders of the burned charge as thoroughly as is done in the four-cycle, and to inspire as large a proportion of fresh gas to the volume of the cylinder, as the latter effects. This, however, is just where the greatest difficulty in the development of the two-cycle lies. The fresh gas must be inspired and compressed on the up stroke, fired and exhausted on the next succeeding down stroke, and with the exceedingly limited time-element per function that this necessitates, it has been found practically impossible to clear the combustion chamber of the burnt gases to anything like the degree that is effected in the four-cycle with its intervening idle stroke. The result

is that the fresh charge is always mixed with a greater or less proportion of the burnt gas already in the cylinder, with a consequent decrease in the effectiveness of each of the power impulses as compared with the four-cycle type. Owing to the rapidity with which they follow one another, however, the power output of the two-cycle cylinder is greater than that of a four of the same dimensions, particularly at the more desirable lower speeds.

It is accordingly possible to employ two or three two-cycle cylinders, in place of the usual four-cylinder, four-cycle, which not only further lowers the initial cost, but also serves to cut down maintenance charges. As the power impulses are consecutive in each cylinder during each revolution, a 180-degree crank shaft may be used in the two-cylinder and a 120-degree crank shaft in the three-cylinder, giving practically perfect mechanical as well as impulse balance, thus largely eliminating the destructive effects of vibration. This accounts for the two-cylinder motor shown on the Atlas delivery wagon chassis just referred to, the same motor also being employed on the Atlas taxicabs. The frequency of the power impulses also makes it possible to reduce the size and weight of the balance wheel necessary for a given power.

Just back of the flywheel, Fig. 49, is shown the planetary change-speed gear minus its bands and operating connections. Final drive is by propeller shaft, with a universal joint at each end, to a live rear axle. The frame is of pressed steel, of the usual channel section, with transverse members to stiffen it and support the motor and transmission gear. Suspension takes the form of three-quarter elliptic springs in the rear and semi-elliptic forward. Pneumatic tires are fitted, this, however, being optional with the purchaser. As the car is rated at 1,000-pound capacity the pneumatics may, of course, be successfully employed with advantage both to the machine and its speed. The appearance of the complete car, fitted with a closed type of delivery body, is apparent in Fig. 50, which also illustrates the control, this taking the form of pedals for the low and reverse speeds, and the brake and a short lever for the high speed, as has become practically standard practice in connection with the planetary gear. The Atlas motor is distinguished by the employment of revolving ports in the crank case, which control the admission of the charge. The latter is compressed in the crank case, as high a



ALCO GASOLINE MOTOR TRUCK
American Locomotive Company, New York

precompression as possible being obtained by restricting the volume of the crank case to the minimum. The pressure in the latter reaches

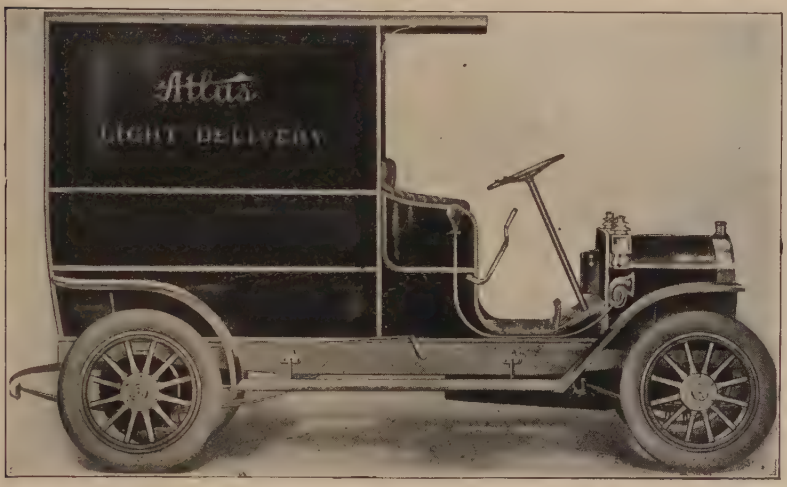


Fig. 50. Atlas Delivery Wagon.

7 to 8 pounds to the square inch, as compared with 3 to 4 pounds in many others, so that a quick transfer of the charge is effected.

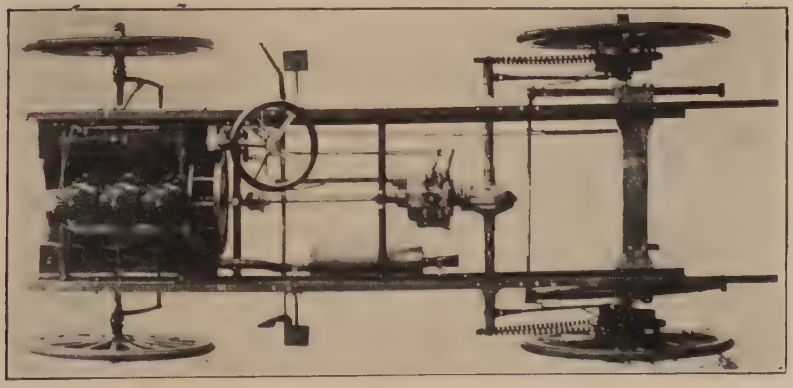


Fig. 51. Chase, Model D, Chassis.

Chase. A radically different type of two-cycle delivery wagon is illustrated by the plan view of the chassis of the Chase, Fig. 51. As will be noted, this is equipped with a three-cylinder, vertical, two-cycle motor, rated at 18 horse-power. The flywheel is made in

the shape of a blower and draws a large volume of air over the cylinders, effectively cooling them. Drive is by shaft to a two-speed planetary change gear of special type, located just forward of the countershaft carrying the differential, from which the final drive to the rear wheels is taken by side chains in the usual manner, the wheels themselves being of the ordinary wagon type, fitted with small solid rubber tires. The appearance of the complete car with panel-top delivery body may be judged from Fig. 52. It has a rating of 1,500 pounds

Fig. 52. Chase Delivery Wagon with Panel Top.

useful load capacity, and as the construction throughout is very light, its efficiency should be high. The same makers also list a two-cylinder, two-cycle, 12-horse-power delivery wagon of 500-pound capacity, the total weight of the machine with an open express type of body being 1,400 pounds.

Templeton-Du Brie. The Templeton-Du Brie is another two-cycle commercial vehicle which has recently been placed on the market by a Detroit company of the same name. It differs totally from either of the foregoing in that it is equipped with a differential-piston type of two-cycle motor. The latter has two cylinders, and the pistons are cast with two diameters, the upper, or working half,

having a 4½-inch bore and stroke, while the lower, or fuel-compressing half of the piston measures 6 inches in diameter. Fuel is admitted through automatic poppet valves from the carbureter to the annular chambers in which the larger diameter of the pistons travel, and is there precompressed to 40 pounds to the square inch. The charge thus precompressed in the annular chamber of one cylinder, is transferred through the medium of a port and an inclined passage to the combustion chamber of the next cylinder, where it is further compressed to 70 pounds to the square inch by the upward stroke of the working piston of the latter.

The transmission is a special form of planetary gear employing disk clutches and is mounted on the rear axle. The forward axle is an I-beam forging and the wheels run on ball-bearings, equalized internal-expanding brakes acting on drums on the rear wheels. The steering gear is of the worm and sector type, while the control is entirely by pedal, the various pedals controlling the low and high speed and reverse being interlocked in such a manner that only one can be engaged at a time.

Spring Design. There is a greater difference of opinion on the part of designers regarding the spring equipment than almost any other part of the chassis outside of the motor. With few exceptions, the use of semi-elliptic springs forward is universal and may be regarded as standard; it is in the rear where the greater portion of the load is carried that differences are found. Generally speaking, practice where the latter is concerned is divided between the straight semi-elliptic and the three-member or half-platform type of suspension on heavy and moderately heavy truck types, while the platform, elliptic, and half-elliptic are all found on delivery wagons.

It will be quite evident that the suspension of the average commercial wagon presents no mean problem for the engineer. The springs of the business wagon must work under widely differing conditions during the course of every day's service. Part of the time it will be traveling at a slow speed over smooth pavements with a full load, while the remainder of the time it will run light—frequently over indifferent roads—and there is always a temptation for the driver to speed, regardless of road conditions, when the vehicle is empty. The heavy static load imposed by the full body must be properly provided for, as must also the terrific dynamic stresses occasioned

by bumping the empty wagon over a bad road at high speed. Between these two widely separated limits, the suspension must be such as to afford the greatest protection to the motor and other mechanisms. To illustrate the varying conditions to which the springs of a delivery wagon were subjected as well as the movement of different types of springs, the makers of the Grabowsky power wagons undertook a series of tests, the results of which are very interesting.

The vehicle selected was a Grabowsky 1-ton delivery type with a 102-inch wheel base, 56-inch tread, and 32-inch by 3½-inch solid rubber-tire equipment on all four wheels. The springs were half-elliptic forward and of the half-platform type in the rear. The front and rear side springs were 44 inches long by 2¼ inches wide and had a 5-inch opening when the car was empty. The rear cross spring was 35½ inches long by 2¼ inches wide and had a 5¾-inch opening. The weight of the car empty was 3,650 pounds, of which, after subtracting that of the axles, springs, and steel wheels, there was an actual load of 1,700 pounds on the front wheels and 950 pounds on the rear. A simple, graphic recording instrument was devised to show the extent to which the springs moved, different cards being inserted as the conditions changed.

To start with, a stretch of asphalt pavement was tried and three tests run. This pavement had the usual number of small holes or depressions, which are unavoidable, even on a well-kept road. The car was run over this pavement for some distance without any load at an average speed of 15 miles an hour. The cards showed the springs to be riding very easily with a normal motion, and with very little rebound, averaging approximately 1¼ inches above the center line and about ¾-inch below in the case of the front springs, while the rear side moved but slightly more than this and the end cross spring averaged but little more than ⅝-inch in either direction. Next, a block-paved street which had already passed its initial stage of smoothness was experimented upon and a second series of cards run off. The latter preserved the same characteristics as the first series where the compression and rebound (the former representing movement below the center line of the card and the latter above it) were concerned, but also revealed a far greater range of action, doubtless due to bad spots in the road, the compression reaching a maximum of 1⅝-inches and the rebound 2 inches. This was likewise

true of the third series, which were taken over a stretch of very rough and uneven road, including a bad railroad crossing, the compression in this reaching $2\frac{1}{4}$ inches and the rebound $1\frac{3}{4}$ inches. The cards in question were all taken with the vehicle light.

To make the tests comprehensive, a load of 2,550 pounds was then put on the wagon and distributed as uniformly as possible. The total weight of the car and its load was then 6,200 pounds, which, after the proper deductions for the wheels, springs, and axles were made, left a net load of 2,000 pounds on the front springs, and 3,200 pounds on the rear springs. It will be noted that the load in question was 25 per cent in excess of the rated capacity of the machine. Under it, the front springs closed $\frac{7}{8}$-inch and the rear closed 3 inches, the rear cross spring settling $2\frac{1}{8}$ inches. With a normal load, this compression would have been correspondingly less, but the test was purposely carried out with an overload because of the frequent overloading by the owners themselves in active service. It is more or less common practice for commercial-vehicle owners to exceed the rated capacity of the machines. The road selected was even worse than that over which the wagon had been driven for the last series of empty trials. It was found that the compression and rebound retained almost exactly the same relation to each other that they had before, though the range of movement under sudden stress was naturally greater, reaching as high as $2\frac{1}{2}$ inches in either direction, this being experienced as the result of dropping into a depression after crossing a railroad track. Another make of car having platform springs both front and rear was tested as a comparison. The sides of the platform were 36 inches and the rear members 37 inches in each case, the springs being $2\frac{1}{4}$ inches wide. Normally, they stood open 7 inches, closing $1\frac{3}{4}$ inches under a load of 2,000 pounds. Owing to the poor material employed and the stiff construction necessary to make it stand up, an extremely jerky and uncomfortable movement of the car was produced. The steel employed was of such poor quality that the springs soon took an excessive permanent set, and after a comparatively short period of service lost their springiness altogether.

GASOLINE TRUCKS

As is the case with the electric vehicle, there is no sharply defined line of demarcation between the gasoline delivery wagon and the gasoline-driven truck. Owing to its far greater proportion of power to weight and the fact that its radius of travel is not limited, as in the case of the electric, load carrying capacity is not as closely restricted. It is almost as economical to operate a 1,500 to 2,000-pound wagon of the gasoline type, as it is a 1,000-pound vehicle and the larger vehicle will stand up better under heavy duty. Even though the loads be such as could practically always be transported on the lighter vehicle, the heavier wagon represents a better investment in the end, despite the increased first cost, except in cases where the average load is such as to fall considerably below the normal carrying capacity of the 1,000-pound wagon. Hence, there is even less difference between the heavy gasoline delivery wagon and the light gasoline truck, than is the case between the electric of these two types. Such cars as the Rapid, Autocar, and Randolph of 1,500- to 2,000-pounds capacity are accordingly fitted by their makers with open stake, express, or closed delivery bodies, and in the case of the Rapid are also utilized as buses or sight-seeing wagons having a capacity of 12 to 16 persons.

It is in the transportation of heavy loads that the gasoline-driven vehicle shows to the greatest advantage on a ton-mile basis, as well as in speed of delivery, as its ability to travel is not hampered by power restrictions. It has been pointed out that with an increase in load-carrying capacity, not alone the traveling radius but the speed of the electric is greatly reduced, and as the radius of travel increases with a reduction in the discharge, it is accordingly not economical to attempt to run a heavy electric at more than a very moderate speed. 5-ton and 10-ton trucks driven by electric power are not capable of being driven at a speed much in excess of 4 to 6 miles an hour, and even at this low rate of travel, their radius is rather limited, while the great amount of battery necessary tends to cut down their efficiency somewhat. For this reason, electric vehicles have, in the main, been confined to the light and medium capacity types, though not a few 5-ton and some 10-ton trucks are in operation. The total number, however, is insignificant as it is difficult for them to compete on an even basis with the gasoline-

driven commercial vehicle in the transportation of heavy weights. Speeds of eight miles an hour are easily attained by 10-ton trucks of the latter type, and at this rate of travel they are most economical of fuel when carrying full load. This is not their maximum speed even with full load, as they can be run as fast as 10 miles an hour, with an increase to 11 or 12 miles an hour when empty.

Air-Cooled Motors Show High Load Efficiency. Mention has already been made in connection with the description of electric delivery wagons that load efficiency, or the amount of useful weight that may be carried in proportion to the weight of the vehicle itself, increases rapidly with the size of the vehicle. This, of course, varies not alone with the make of vehicle, but also with the type, those employing air-cooled engines naturally having a great advantage in this respect. Take the Franklin 1,000-pound wagon as an example. The weight of the chassis is but 1,800 pounds, which gives it an apparent efficiency of 62.5 per cent. Naturally, the load cannot be carried on the chassis, but as the bodies employed vary so much in design and weight, the manufacturer usually lists the weight of the chassis alone. In the case just cited, the addition of an open, stake body or a closed, delivery type would add two- or three-hundred pounds, making the actual efficiency of the vehicle slightly in excess of 50 per cent. In the case of the one-ton Franklin truck, the increase in efficiency is strikingly illustrated, as the increase in the weight of the chassis itself is merely nominal, so that even with the addition of the body and in complete running order with a supply of fuel and oil, the load efficiency is close to 100 per cent. An equally favorable showing is made by the Knox trucks equipped with an air-cooled type of motor. For instance, the Knox 1,500-pound, air-cooled machine has a chassis weight of but 1,800 pounds, while the chassis of the 2,500-pound size only tips the scale at 2,100 pounds. This difference is even more accentuated in the 3-ton, or 6,000-pound truck, Fig. 53, the chassis of which weighs but 5,100 pounds. To cite further examples of relative weights which show a very favorable efficiency due to the same cause, the Knox 3,000- and 4,000-pound, air-cooled chassis may be mentioned, Fig. 54. These weigh 3,260 and 4,200 pounds respectively. It will be noted from the fact that not alone the type of motor and the style of body have a direct and important influence on this, but likewise the tire equipment, as the

Fig. 53. Knox 6,000-Pound-Capacity Truck

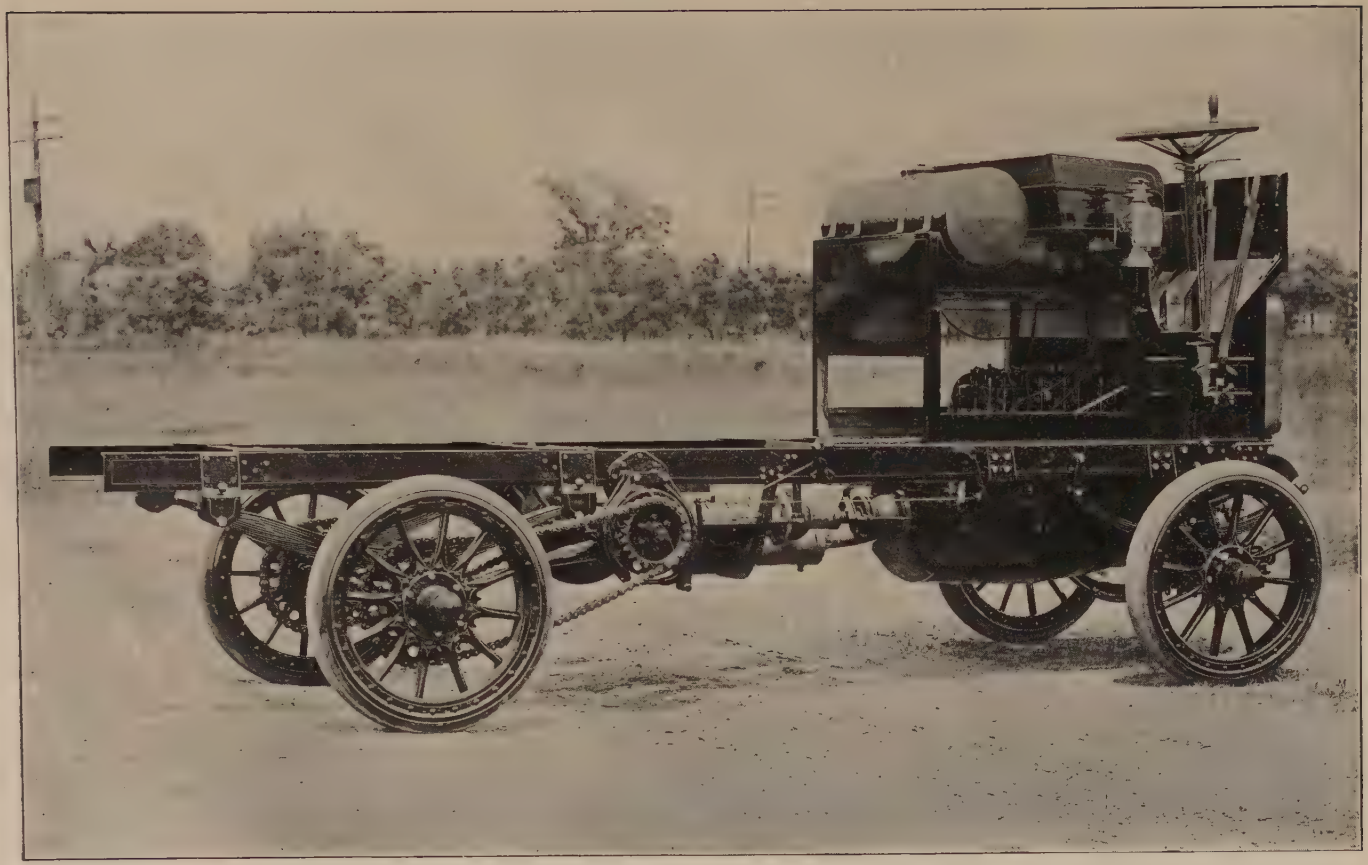


Fig. 54. Knox 4,000-Pound Chassis.

Fig. 55. Knox 4-Ton Stake Truck

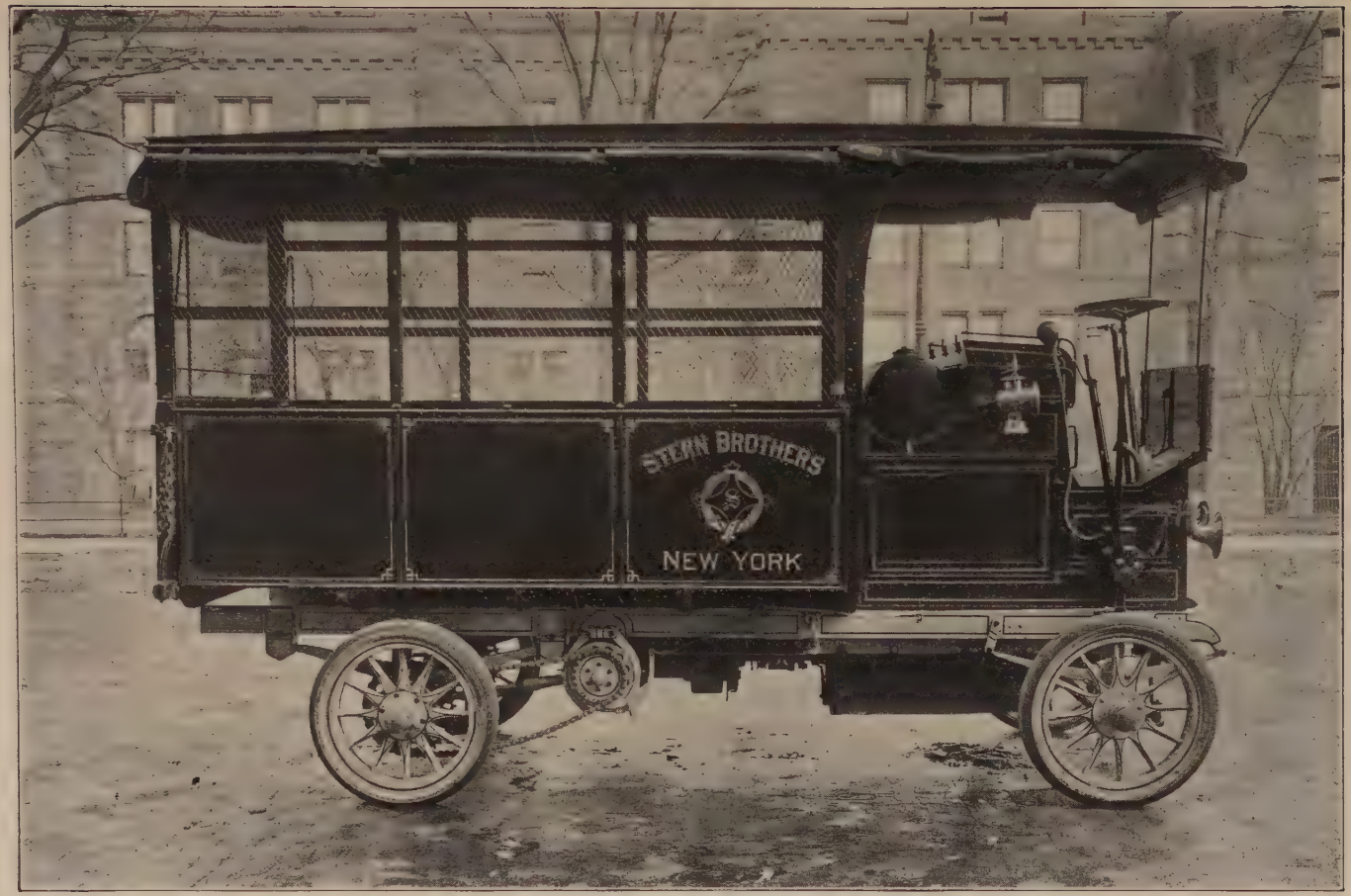


Fig. 56. Knox 2-Ton Screen-Top Var.

4,000-pound Knox air-cooled wagon has a chassis weighing but 3,600 pounds when designed for pneumatic tires, as compared with 4,200 pounds for solid rubber tires. Fig. 55 shows a Knox 4-ton truck, and Fig. 56, a 2-ton truck. Equally high efficiencies are shown by the Frayer-Miller air-cooled trucks.

Load Efficiency Increases with Size. Above the 2-ton size, it will be apparent that the load efficiency either very closely approximates 100 per cent, or actually exceeds it by a constantly increasing margin as the size of the vehicle increases, as, once a certain point is reached, additions to the weight caused by increasing the dimensions of the load-carrying space and adding to the power of the motor are disproportionately small as compared with the increase in load capacity. Thus the American Locomotive truck of 3-ton capacity has a chassis weighing but 4,500 pounds, and tips the scales at only 5,200 pounds completely fitted, or "all on"; on the other hand, the Manhattan chassis for the same nominal carrying capacity, *i. e.*, three tons, weighs 6,000 pounds. However, as no standard for rating the load-carrying capacity of gasoline trucks has ever been attempted, and one maker's 5-ton truck is sometimes no larger than the 3-ton truck of another, it is difficult to always make comparisons that will be fair on a basis of catalogue weights alone. The custom that grew up in the pleasure-car field of greatly underrating the weight has doubtless had its influence here as well, and some of the figures are probably nothing more than "catalogue weights," but under the circumstances, they represent the only data available. Another great source of difference that is practically impossible to reconcile is the extreme variation between the dimensions of the bodies which are given the same load-carrying capacity by different makers. In fact, this may well be illustrated in the product of one maker. The Knox 4,000-pound car, equipped with a 48-horse-power, water-cooled motor, and 40-inch by 6-inch pneumatic tires, tips the scale at only 4,000 pounds. This is likewise true of the same type of car of 40 horse-power and 4,000-pound load capacity equipped with 34-inch by 4- and 5-inch solid tires, and at first sight, it would seem that the pneumatic tires did not influence the result in this case. A little further investigation of the specifications, however, reveals the fact that the pneumatic-tired vehicle has a wheel base of 145 inches and is capable of speeds up to

40 miles an hour, while the solid-tired car is only 103 inches on the ground and its maximum speed is but 15 miles an hour.

To give an illustration of the increase in load efficiency with the increase in capacity, some of the larger types of Knox cars may be cited, reference to the different models of the same maker tending to produce a greater uniformity of result than where various makes are compared, owing to the many points of divergence which make comparisons difficult. Thus, the Knox 4-ton truck has a chassis weight of but 5,400 pounds; the 5-ton, 5,600 pounds; and the 7-ton, 6,500 pounds. The Manhattan 4-ton truck has a chassis weight of 6,600 pounds; the 5-ton, 7,200 pounds. Fitted with a special steel dumping body of heavy construction, the complete weight averages 10,000 pounds, thus giving it an efficiency of practically 100 per cent in this respect. While the efficiency of a passenger bus can naturally not be calculated on the same basis, it is interesting to note that the Manhattan 16-passenger bus averages 6,800 pounds, complete with body and fittings; and the 22-passenger type, 8,000 pounds. These two correspond with the 3-ton and 5-ton trucks, but the bodies naturally are heavier.

Types. The points of difference in design, construction, arrangement of the essentials, and other details are quite as diversified as in the case of the delivery wagons. So, in order to give a comprehensive idea of what will doubtless form one of the most important automobile types of the future, and which is, in fact, destined to eliminate the horse from this field almost entirely, a number of makes are described more or less at length and their differences or correspondence with others made clear.

Franklin. Both the Franklin 1,000- and 2,000-pound light trucks are really on the dividing line between the light truck and the delivery type, as either may be used for one or the other purpose, depending entirely upon the body with which it is fitted. The cars have as their motive power an air-cooled motor of a special type. In the case of the 1,000-pound wagon, it has four independently-cast cylinders of $3\frac{3}{4}$-inch bore by 4-inch stroke, and rated at 18 horsepower. Vertical flanges are placed on the outside of the cylinders, covering the entire stroke of the piston, and are surrounded by light jackets open at the top and bottom, while the entire motor is also encased in a light sheet-steel housing reaching half-way up the cylin-

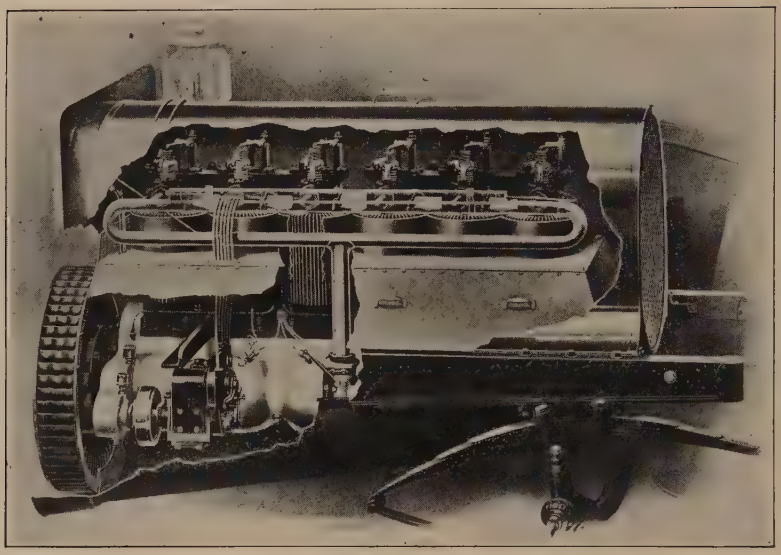


Fig. 57. Franklin 6-Cylinder, Air-Cooled Engine.

ders. This is to compel all of the air drawn in by the powerful suction fan—which also forms the flywheel—to pass down through the air jackets of the cylinders and over the cooling flanges, then through the fan and out at the rear of the car beneath the body. A

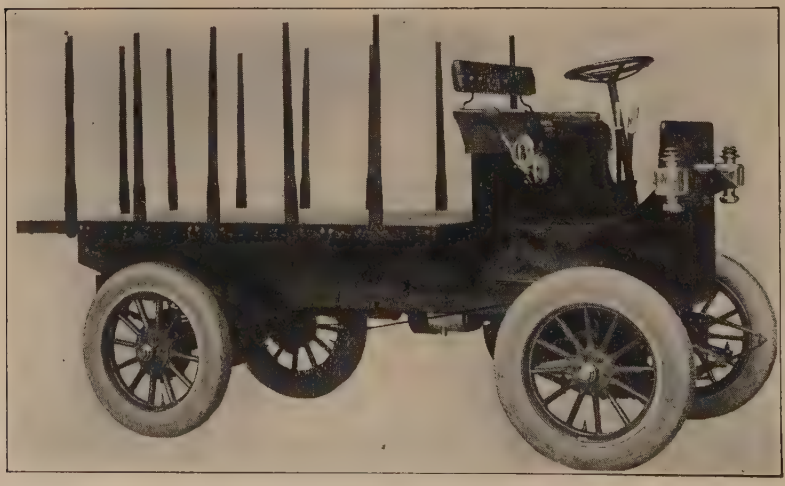


Fig. 58. Franklin Truck with Stake Platform.

clear idea of this construction may be obtained from Fig. 57, which shows a six-cylinder motor of the Franklin air-cooled type.

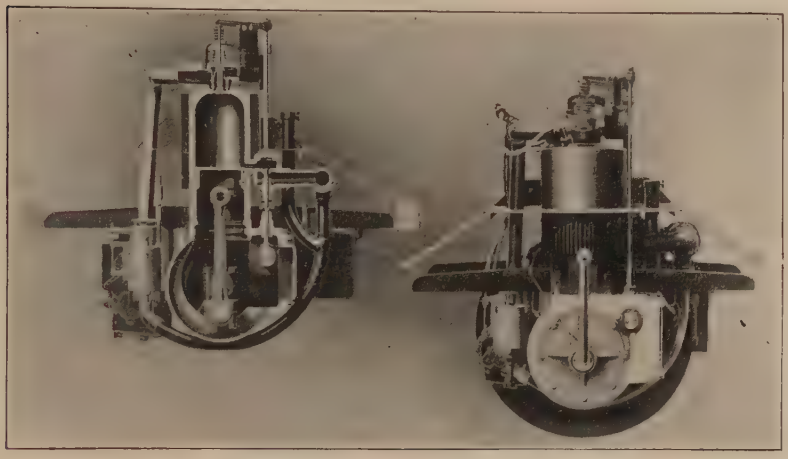


Fig. 59. . Section and Front View of Franklin Engine.

In the case of the truck, a different form of bonnet is employed, for the motor is mounted directly beneath the footboard, as will be noted from Fig. 58, which illustrates the complete Franklin chassis of the

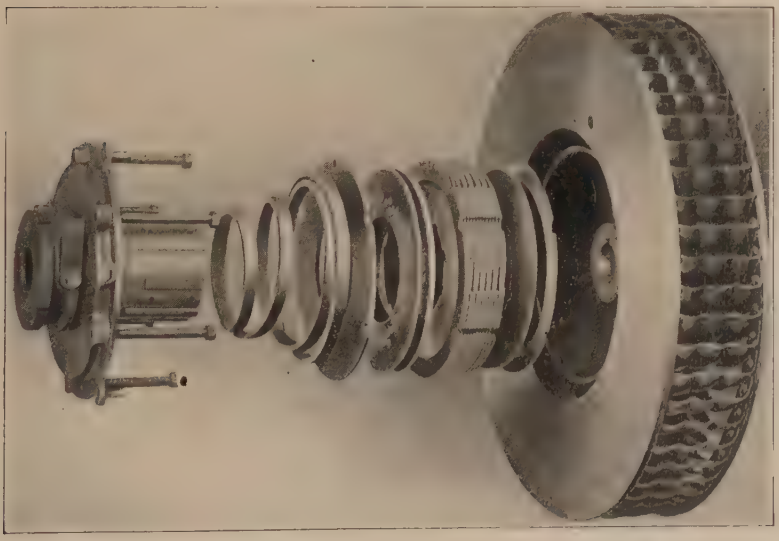
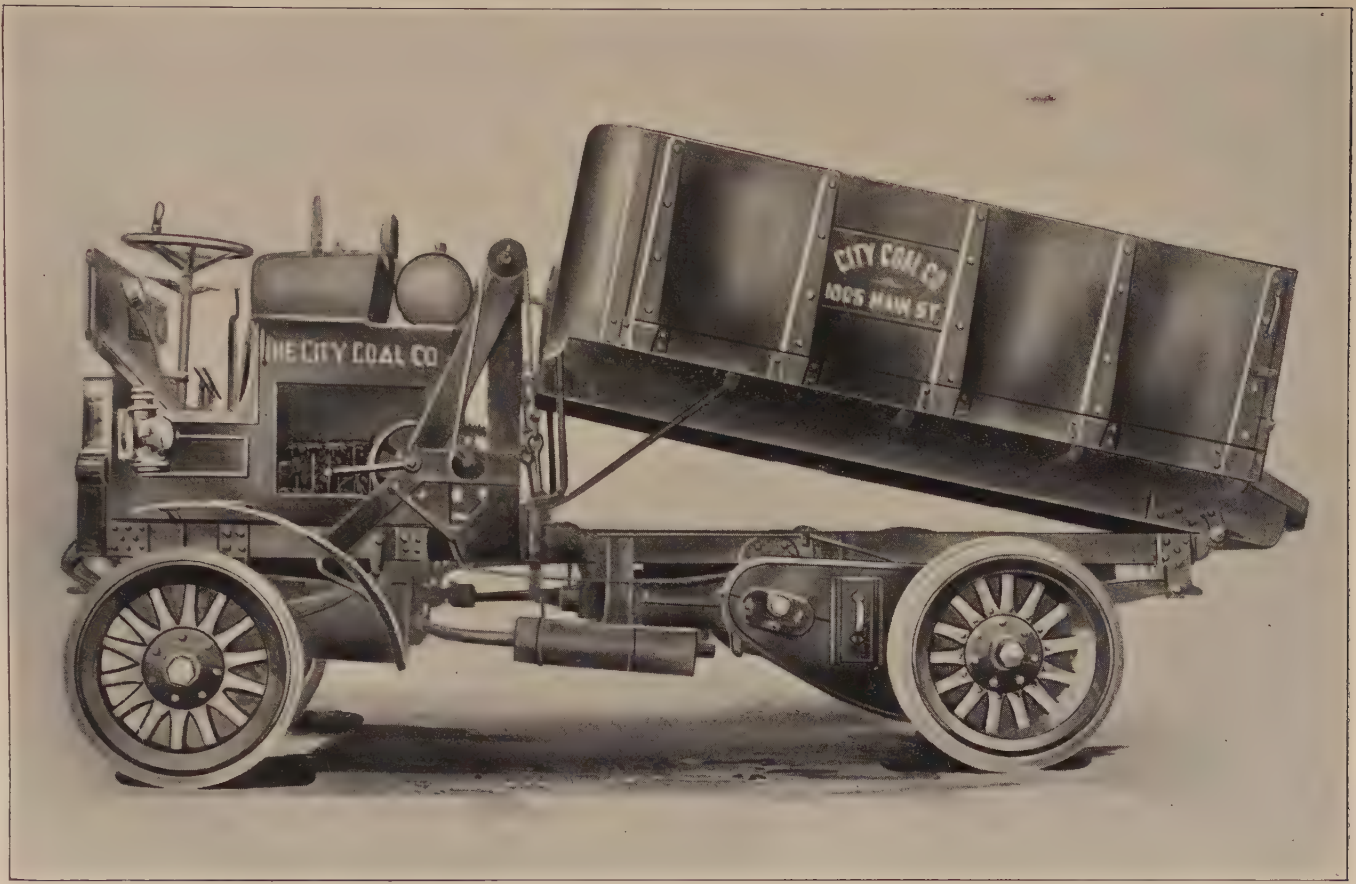


Fig. 60. Suction Flywheel and Dissected Clutch of Franklin Engine.

2,000-pound size. Further details of the motor construction are shown in Fig. 59, the sectional view of which serves to illustrate the auxiliary exhaust distinguishing the Franklin motor, while the construction of the suction-blower flywheel, and the details of the multiple disk clutch employed, are shown in Fig. 60. The same size motor is employed on the 2,000-pound as on the 1,000-pound truck, and the gear ratio on both is 6.83 to 1. In fact, their specifications throughout are practically identical, there being but 50 pounds difference in the weight. The construction throughout is the same as that of the Franklin pleasure cars, a laminated wood frame, tubular-front and rear axles being used, the latter of the semi-floating type. The springs are 40-inch, full-elliptic in front, with semi-elliptic and coil springs in the rear. A sliding gear of the progressive type, giving three forward speeds and reverse, constitutes this element of the transmission, final drive being by propeller shaft. All brakes are of the external, contracting type, one being placed in a drum on the hub of each rear wheel, and one on the transmission drive shaft. Instead of the usual bevel-gear drive, a worm and pinion are employed. The tire equipment consists of 37-inch by 5-inch Goodrich quick-detachable pneumatics on the 1,000-pound wagon, and 36-inch by 5½-inch tires of the same make and type on the larger wagon.

Knox. As practice in the commercial field is not hampered by prejudice or other unfounded bias as in the pleasure-car field, but is based purely on results figured on initial cost and expense of operation, the air-cooled motor is now much more in evidence in the business wagon than it is in the car built merely for pleasure. Thus no less than six different models of cars equipped with air-cooled motors are listed by the makers of the Knox machines, who confine themselves entirely to the water-cooled motor in pleasure-car design. These range from the single-cylinder, 1,500-pound delivery wagon, the motor dimensions of which are 5-inch bore by 8-inch stroke, rated at 8 horse-power, up to the 3-ton truck, fitted with a four-cylinder motor, having 4¾-inch by 5½-inch cylinders and rated at 36 horse-power. Between these two extremes, there is the 2,500- and 3,000-pound wagon which has a two-cylinder, 5-inch by 7-inch, 20-horse-power motor. The Knox motor is cooled by means of a large number of successive series of corrugated pins which are tapped into



KNOX MODEL R-16 FOUR-TON COAL TRUCK WITH HAND DUMPING BODY

Knox Automobile Company, Springfield, Massachusetts

the outside face of the cylinder and are placed in staggered relation to one another to deflect the currents of cool air passing over them. Both the single-cylinder and two-cylinder cars are fitted with a regulation planetary two-speed gear and chain drive, while the 4,000- and 6,000-pound wagons having 36-horse-power, four-cylinder motors, have a three-speed sliding gear of the selective type, Fig. 61. While the latter naturally differ to a greater or less extent in detail from many others of the same kind, their design may be regarded as typical of those generally employed, so that the following description

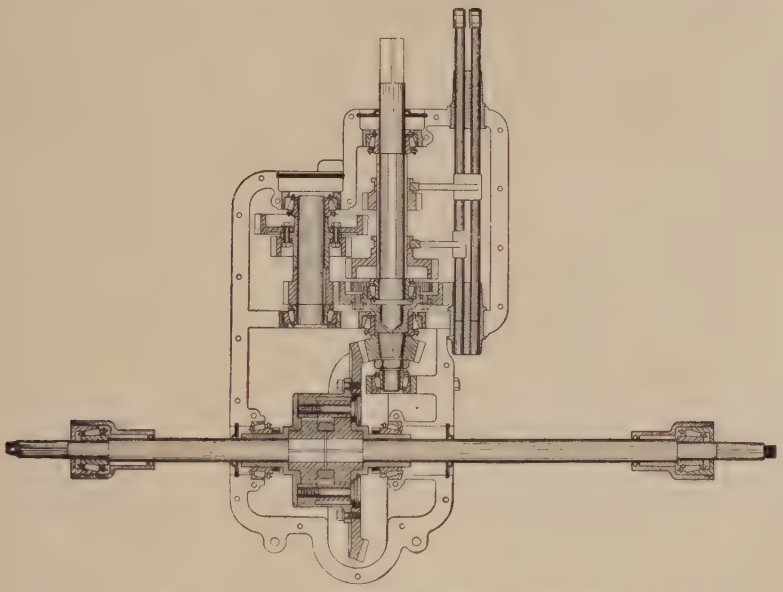


Fig. 61. Knox Three-Speed Selective Transmission.

may be taken to cover the majority, with a few amendments, such as the employment of annular ball-bearings, instead of the roller type shown in the illustration. The main driving shaft may be seen extending forward with a flange at its right-hand end for coupling to the shaft from the clutch. Parallel with it are the operating rods which carry yokes adapted to move the gears back and forth, according to the position of the hand lever, which picks up one or the other of these short operating rods, in accordance with which side of it is moved, or, when in a sector, which slot of the latter it is in. Thus the rod and its yoke farthest away from the main driving

shaft, controls the first speed forward and reverse, the last-named through an extra pinion underneath it, not plainly visible in the illustration. The inner rod controls the second and third speeds forward, and as shown, is in the second speed engagement. For the third or high speed, usually known as the *direct drive*, the two parts of the main driving shaft are locked together so that the power of the motor is then transmitted directly from the clutch to the bevel pinion and large gear without the intermission of any other reduction. This large bevel also incorporates the differential, which is mounted on the countershaft. At its outer ends, this countershaft carries sprockets of small size, driving by means of side chains to larger sprockets on the rear wheels, these constituting a further reduction in the speed between the motor and the drivers. On the high gear, the ratio is 6.75 to 1, which, at 1,500 r. p. m. of the motor, equals 222 turns of the 36-inch wheels with which the car is equipped, and is equivalent to a maximum speed of 22.6 miles per hour. The gear ratio of the second speed is 11.81 to 1, and at the same motor speed, it turns the rear wheels 127 times per minute, which is equal to 12.2 miles per hour. The first, or low gear is 27 to 1, or 5.8 miles per hour, while on the reverse, it is further decreased to 34.6 to 1, or 3.2 miles per hour. A substantial lock is provided to prevent attempting to engage two speeds, while a strong spring tends to throw the shifting lever into the neutral position whenever it passes that point. The complete gearset and its case weighs 600 pounds.

Frayer-Miller. The Frayer-Miller is a further type employing an air-cooled motor, and, in fact, was the first of its kind built in this country to incorporate a blower for cooling the engine. This blower, which is of the vane, or centrifugal type, takes the place of the fan ordinarily employed on water-cooled motors and is driven by gears from the crank shaft in much the same way, but, as its capacity has to be much greater, the construction throughout is very much more subsfantial. The blower delivers a large volume of air to a manifold which is led up and along the top of the cylinders, opening into the upper ends of light air-jackets which surround the heads and working length of the cylinders. The latter are fitted with radiating flanges past which the air is forced, issuing at the open ends of the bottom of the jackets. Contrary to the usual practice, the valves are placed in a vertical

plane and face one another in a special valve chamber mounted on the cylinder head, thus getting the direct benefit of the cooling current of air. As motor trucks and delivery wagons are run at slow speeds and with frequent stops as compared with a pleasure car, the blower system, represented by the Frayer-Miller and the Franklin, is an advantage as it makes the cooling of the motor entirely independent of the speed of the car. In the truck types, the Frayer-Miller is listed in 1½- to 2-ton and 3-ton sizes. Except for slight differences of dimension, the specifications are practically identical in both cases. The motor has four 4¼-inch by 5⅛-inch cylinders and has a nominal rating of 28 to 30 horse-power. A selective sliding type of gearset, providing four forward speeds and one reverse and having its shafts mounted on annular ball-bearings, is employed. This is connected by a short propeller shaft having two universals to a countershaft, from which the final drive is taken to the rear wheels by side chains in the conventional manner. The axles are solid forgings of square section, 36-inch wood artillery wheels being used on both trucks, with 4-inch single, solid-rubber tires front and 3½-inch dual type on the rear of the larger machine, and 4-inch front and 5-inch single rear on the lighter type. The front springs are semi-elliptic, with a three-member semi-platform suspension at the rear. Both the foot brake and the emergency operate in drums on the driving wheels. The wheel base is 118 inches on the 2-ton and 128 inches on the 3-ton truck with a 66-inch tread, this permitting of a loading space measuring 12 feet long by 56 inches wide in the clear.

Rapid. By referring to "Gasoline Types of Delivery Wagons," Page 53, it will be noted that chassis of the smaller size just described are also listed as delivery wagons. This is the case with the Frayer-Miller, the makers of which list the smaller of the above chassis, with but slightly reduced dimensions, for delivery-wagon service. This is likewise the case with the Rapid, which, for delivery work, is of unusually substantial construction. In the case of the Rapid, the following differences in dimension suffice to sum up the points of variance between the one-ton delivery chassis, and the 1½-ton to 2-ton light truck. The two-cylinder, horizontal, opposed motor has a 5¼-inch bore by 5-inch stroke with an output of 30 horse-power, as compared with 24 horse-power for the smaller. 2-inch axles are employed with 32-inch wheels front and 34-inch wheels rear, the total weight

of the chassis being 2,676 pounds, giving a comparatively high load efficiency, even on a $1\frac{1}{2}$-ton basis.

But the difference between the requirements of heavy-duty trucks —in which class may be included those of 3-ton capacity and upward —and those of lighter weight is proportionately as great as the difference between the requirements of the pleasure car and the delivery wagon intended for constant service. The ratio of increase in the stresses imposed on the vehicle by an increase in the dead-load capacity was frequently not given sufficient consideration in the design of earlier trucks. It was often erroneously assumed that it was not even necessary to increase power and dimensions in quite the same proportion as the load increased. While this is true to a great extent, and particularly at the present time, it was not many years ago that neither materials nor design were up to the requirements. For this reason, some builders very prudently adhered to the manufacture of the lighter-capacity chassis for several years before attempting heavy-duty trucks, the experience gained in the former field being utilized to great advantage in the latter. The most common of early errors was naturally that of attempting to use practically the same chassis for commercial service as was used for the pleasure car. Under the greatly increased strain of commercial service, clutches, transmissions, and axles that did excellently on the pleasure car, here proved an unremitting source of trouble, which did much to discredit some of the first attempts.

A study of the conditions obtaining in the heavy-truck field, as compared with the requirements of lighter vehicles, is responsible for the striking difference shown in the design of the Rapid 3-ton and 5-ton trucks when placed beside those of the same cars for loads up to 2 tons. Instead of the two-cylinder, horizontal motor, a four-cylinder, vertical motor, Fig. 62, with cylinders of $4\frac{3}{4}$-inch bore by $5\frac{1}{2}$-inch stroke, and giving 45 horse-power, is employed. By noting the different ratings and cylinder dimensions of the various truck motors described, it will be found that there is quite as much divergence in this respect in the commercial field, as in that of the pleasure car. Ample provision for lubrication—the prime necessity of the commercial car motor—is made on the Rapid by installing a gear-driven force-feed oiler with a capacity of 10 pints, a return pump taking care of the surplus oil in the crank case. As there are few things about the

mechanism of a truck so essential to its operation as adequate provision for continuous lubrication, the equipment for this should be one of the first things looked to in examining a machine for its fitness for heavy duty. Next to this come the ignition and the cooling equipment, as upon these two depend in very large measure the reliability of the car. The Rapid trucks are fitted with a Bosch high-tension magneto—which constitutes an independent and self-contained system of great dependability—and a reserve system comprised of a four-unit vibrator coil and timer supplied by a set of storage cells. Two sets of spark plugs are employed, thus making each system

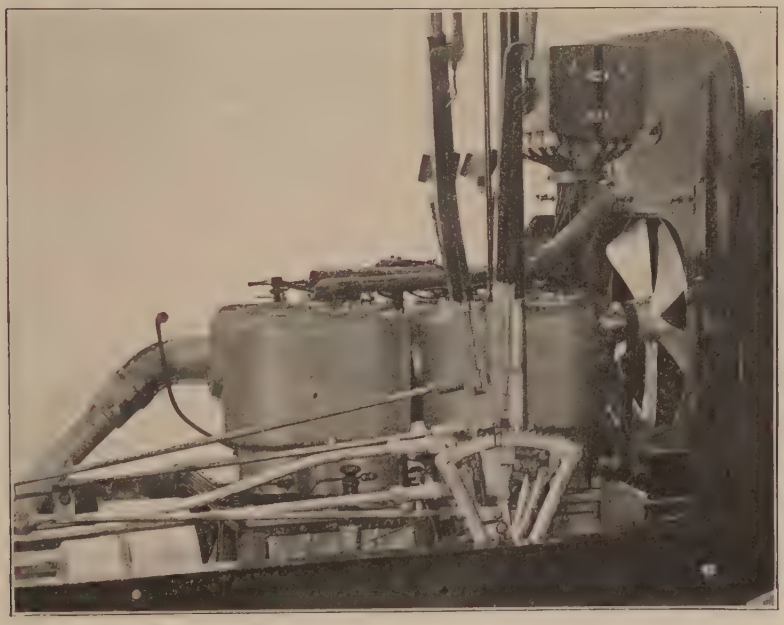


Fig. 62. Rapid 45-H. P., Four-Cylinder, Vertical Motor.

entirely independent of the other. This is an excellent feature, as in the severe service which heavy trucks are called upon to perform, every precaution must be taken to insure absolute reliability, and while a high-tension magneto of standard make has proven to possess the highest measure of reliability, it is essential that the possibility of failure should be guarded against, as this might occur just at a time when a breakdown might mean the delay of a valuable load of merchandise in transit. The battery system is also a great aid in starting

the heavy motors usually employed on trucks, as the motor will often take up its cycle simply by switching on the current, or with but little cranking, although the magneto has now been developed to a point which makes starting very easy, and thousands of cars carry no other ignition equipment.

The Rapid motor is cooled by means of a large radiator, mounted directly in front of the dash, the water being circulated by means of a gear-driven centrifugal pump. This type of pump has the advantage of permitting the water to circulate through it on the thermo-siphon principle in case it breaks down, which is not the case with the gear pump. The foregoing will make clear the reasons for the preference accorded the types of equipment in question on the best makes of trucks, the accessories in question now being regarded as standard, though in the case of the oiler and pump, there are naturally modifications of design to be found. So far as the remainder of its construction is concerned, the Rapid motor is designed along conventional and generally approved lines.

This likewise applies to the construction of the chassis as a whole, Fig. 63, every effort having been devoted to making it as substantial as possible. A heavy girder type of frame is employed with unusually large springs. The gearset is of the selective sliding type giving three forward speeds and is incorporated in the same housing with the differential on the countershaft. Heavy gears of wide face are used, the shafts being mounted on Timken roller bearings. The gear ratio is $7\frac{1}{2}$ to 1 on the direct drive, giving a maximum speed of 10 miles an hour. The clutch is a multiple-disk type, running in a bath of oil, while the final drive is by means of heavy side chains, a feature of the drive being the use of a Hedgeland equalizing axle in place of the usual differential. This consists of a solid, one piece axle, with an ingenious screw clutch device for driving the wheels, which permits the outer one to run free when rounding corners. The front axle is of $2\frac{1}{2}$-inch by $3\frac{3}{4}$-inch rectangular section, while the rear is a $3\frac{1}{2}$-inch round steel section. Steering is accomplished by means of a differential-screw type of gear. The wheel base is 138 inches, giving a loading space of 12 feet in length. The weight of the complete chassis is 6,000 pounds.

The suspension of the Rapid trucks is of the conventional semi-elliptic front and half-platform rear springs, but is characterized by the

use of an auxiliary spring over the rear axle, to supplement the regular springs when the truck is loaded beyond its normal rating. Trucks of this type are intended for the service of brewers, ice, coal, and lumber dealers, iron works, flour and sugar mills, and similar employment involving the transportation of heavy loads.

The vehicle just described is rated as having 3-ton to 5-ton load capacity, the same makers listing a heavier type designed to carry

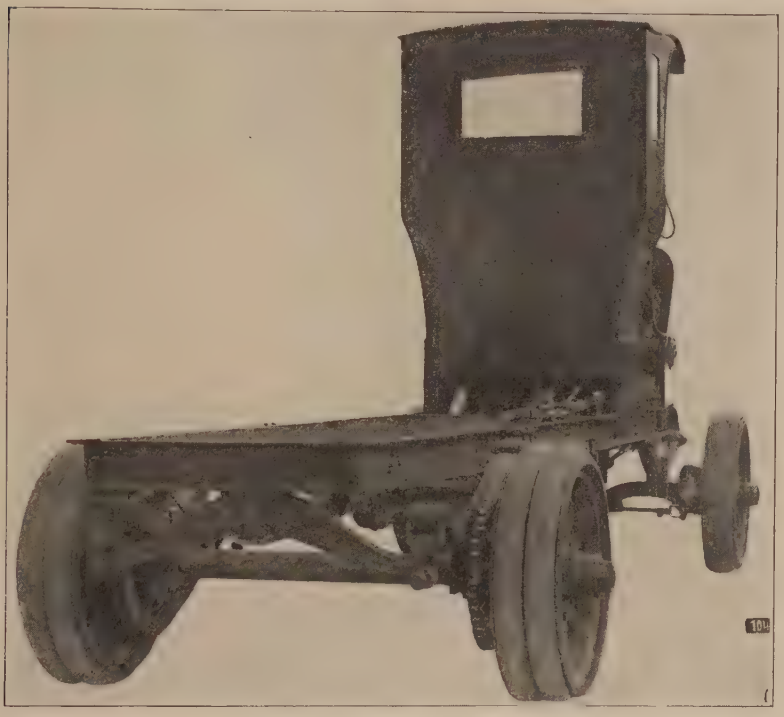


Fig. 63. Rapid 5-Ton Chassis.

5 tons to 7½ tons. Its specifications are the same with the exception of differences in dimension. A 60-horse-power motor is employed, the frame being of 6-inch rolled steel channels, with proportionally heavier axles and springs. The wheel base is 160 inches, giving a loading space of 14 feet, while the weight of the chassis is 7,500 pounds.

American. The American trucks, which are listed in 1-, 1½- to 2-, 3-, and 5-ton sizes, are characterized by the use of a governed motor, a sliding gearset in the smaller sizes, a wood frame, and a special type of planetary, with disk clutches on the 3-ton and 5-ton types.

The governor employed on the motor is of the centrifugal type, acting directly on the throttle, and is a feature of considerable advantage in commercial work, as it not alone prevents racing of the motor between gear changes—which is detrimental—but may also be set so that the driver cannot exceed a certain speed. The 1½- to 2-ton size is fitted with a 35- to 40-horse-power motor, while a 55-horse-power motor is installed on the 3-ton size, and a 65-horse-power on the 5-ton size. Drive is by countershaft and double chain in the usual form, in every case, an I-beam axle being used forward and a solid square axle in the rear. The suspension is of the conventional,

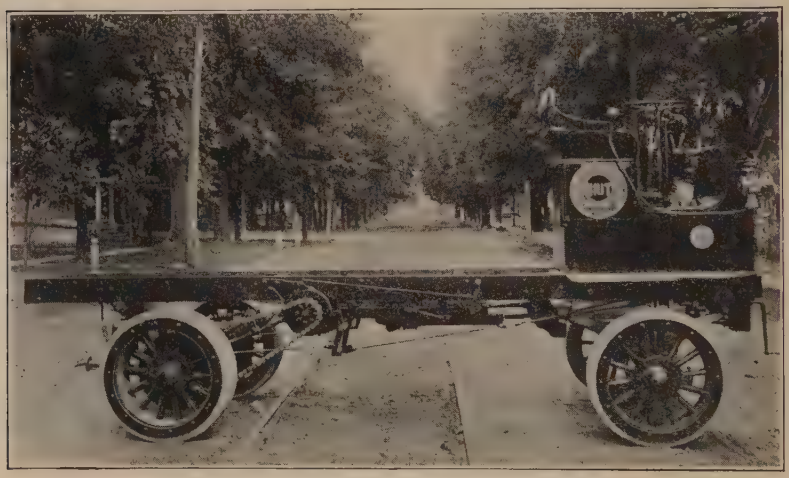


Fig. 64. American 5-Ton Truck with Wood Frame.

straight, semi-elliptic type forward and platform, three-point, spring member in the rear. A view of one of the American chassis is shown in Fig. 64.

Manhattan. The Manhattan trucks are of considerable interest, as being among the first heavy types to be placed on the market in this country, their successful operation in sizes ranging from 2 tons to 5 tons, during the past six years, affording ample evidence of the benefits to be derived from a special study of the commercial problem, which led their makers to employ the most substantial type of construction right from the outset. The comparison of weights of chassis for a given load shows that they are considerably heavier than some of the others, so that their theoretical load efficiency would be correspondingly less, but the extra weight would appear to be justified by

the record that these cars have made in service. The motor is a four-cylinder, vertical type, of 5½-inch bore by 6-inch stroke, but with characteristic conservatism, the makers refrain from giving it a power rating. Its output is probably 50 to 65 horse-power at a speed of 900 to 1,200 r. p. m.

The frame is of a heavy girder type and is carried slightly beyond the forward face of the radiator in bow form, providing a bumper which serves as protection for the radiator. This is a small detail

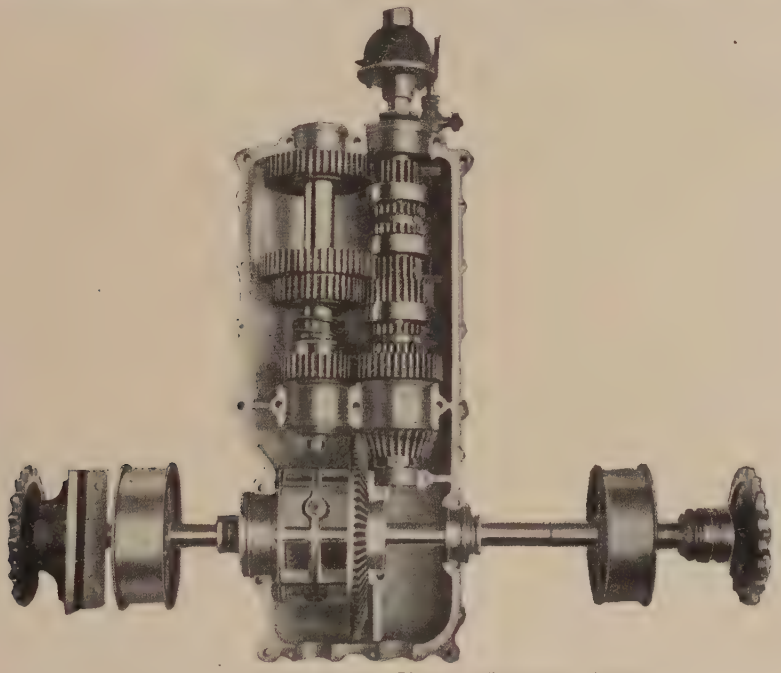


Fig. 65. Mack Transmission Used on Manhattan Trucks.

but is of considerable value in commercial service as bumps are not infrequent and the radiator is the first thing to suffer. A leaky radiator is not alone a source of considerable annoyance, but also of danger to the motor, while a honeycomb type of radiator is difficult and expensive to repair. One of the features of the Manhattan trucks is the employment of an individual-clutch change-speed gear, Fig. 65. While this apparently does not differ from the ordinary sliding type, Fig. 61, it will be noted upon closer examination that the gears are not designed to slide, but remain constantly in mesh. When out of engagement, they are idle on the shaft, being locked by positive

clutches controlled by the usual shifting lever operating in a standard form of H-gate.

The gears, of large diameter and wide face, are carried on substantial shafts supported on Hess-Bright ball bearings. The differential is of the bevel type and is enclosed in the same housing as the gearset, this housing being supported at its after end by the countershaft. From the latter, the drive is taken to the rear wheels by heavy side chains. The countershaft also carries two large drums of wide face, to which contracting bands are applied as brakes, the stresses of braking thus being balanced by the differential as well as by the usual equalizing gear. Internal-expanding emergency brakes are fitted on the driving wheels. The first service in which the Manhattan cars were generally employed was that of sight-seeing cars, station buses, and the like, having a capacity ranging from 12 to 22 passengers. A large number of these cars, fitted with various types of closed and open bodies are now in service. The construction throughout has been standardized by the makers, the same motor and gearset being used on all sizes from the 12-passenger, sight-seeing car up to the 5-ton truck, the difference naturally being in the manner of utilizing the power by varying the gear ratio between the motor and driving wheels. The small buses and sight-seeing wagons consequently are capable of speeds up to 25 miles an hour, while the heavy trucks run from 10 to 12 miles an hour loaded, and up to 15 or 16 miles empty. Owing to the gear ratios necessary to give these low speeds of travel, especially on the first and second gear changes, it would be necessary to race the motor unduly to exceed the speeds in question. For commercial service, the Manhattan chassis are built with capacities of 2, 3, 4, and 5 tons.

Packard. The Packard 3-ton truck, built by the manufacturers of the pleasure cars of the same name, affords an excellent example of the progress that has been made in the development of a truck designed to meet the most severe business requirements. It is the result of several years' study of the problem and was only placed on the market after a thorough trying out of the vehicle from every point of view. The motor is of the four-cylinder, vertical, water-cooled, four-cycle type and is characterized by the same features of design which distinguish the motor employed on the pleasure car. As is the case on the latter, the motor is carried on the forward end of the chassis

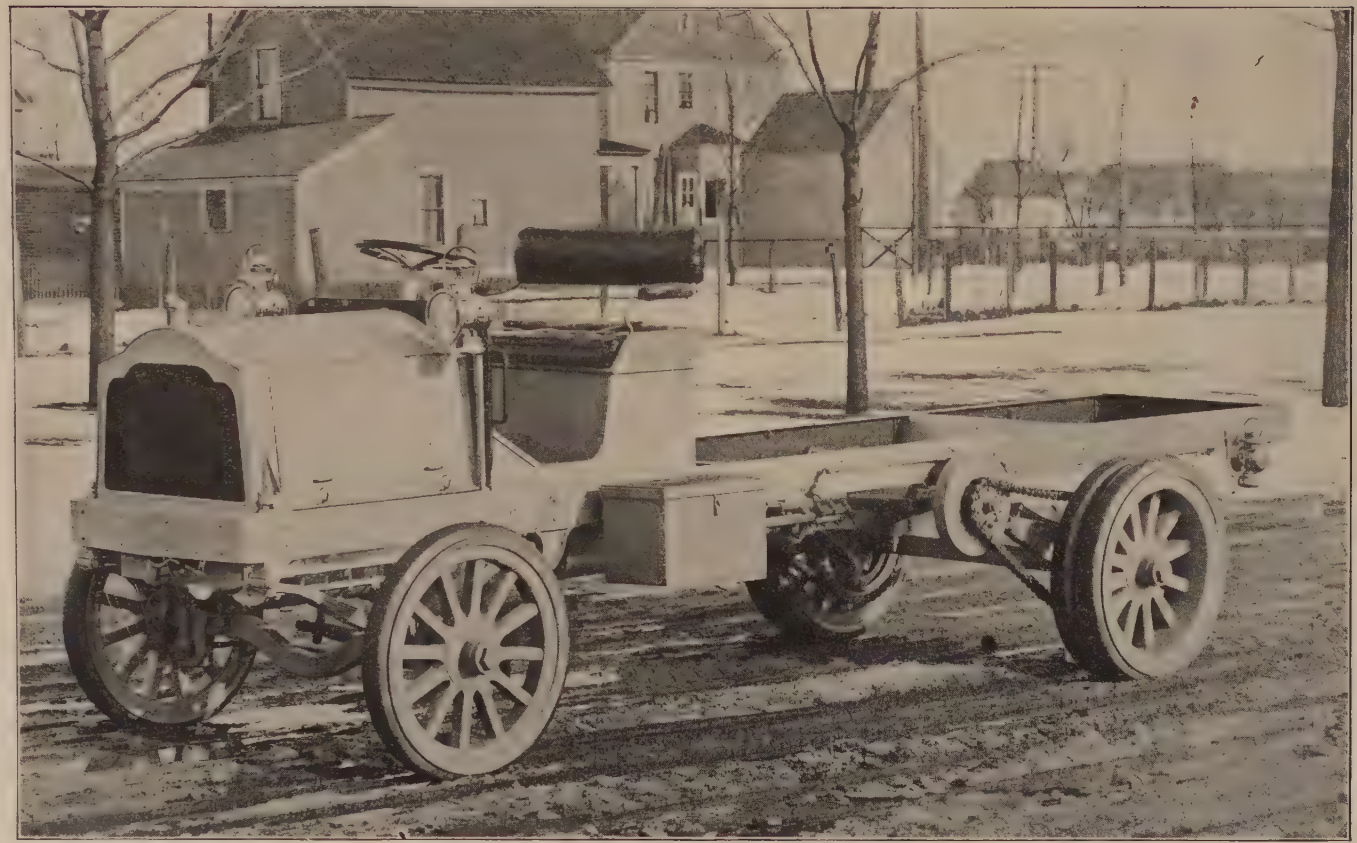


Fig. 66. Packard 3-Ton Truck, Standard Chassis.

under the same type of bonnet, Fig. 66. The cylinders have a 4½-inch bore and a 5½-inch stroke, the motor being designed to develop 24 horse-power at an unusually moderate speed. This makes it capable of giving an output largely in excess of this by simply increasing the speed of the motor, which, due to its low normal r. p. m. rate has a wider range of acceleration without racing than is possible with a higher initial rate. An unusually flexible motor thus results, and the importance of this feature may be appreciated when the low speeds of travel to which the commercial vehicle is necessarily restricted are borne in mind. In other words, the discrepancy between the motor speed and that of the car is greatly reduced, and the necessity for employing a high gear ratio correspondingly lessened.

Cooling is accomplished by means of a cellular radiator, the water being circulated by a centrifugal pump of large capacity. The radiator itself is carried on a trunnion type of mounting which prevents it being affected by any torsional stresses set up by the twisting of the frame. An Eisemann high-tension magneto is employed for the ignition, with a set of storage cells for reserve current. The clutch is what is known as a *dry-plate* type, in which a floating disk having both of its surfaces covered to a large extent with cork inserts, is clamped between plain metal disks secured to the flywheel and the transmission shaft respectively. Changes of speed are effected by means of a sliding gear of the same type as is employed on the Packard pleasure cars, final drive taking the form that has become standard practice in American heavy-truck design, viz, double side chains. To overcome the whipping and jerking effect on the chains occasioned by frequent changes of speed, the countershaft carries two heavy disks, one at either end, just inside the sprocket. These act as balance wheels and keep the countershaft rotating at a practically uniform speed. Heavy stresses suddenly imposed on the chains, as in starting large loads, and in changing from one speed to another, tend to stretch the links and throw the chain out of pitch with the sprockets, thus bringing about rapid wear and making the chains very noisy, while there is also danger of breaking a chain when the stress is more than ordinarily severe. This simple expedient is accordingly becoming generally adopted in truck work.

American Locomotive. An excellent illustration of the adaptability of the internal combustion motor for commercial service is

afforded by the American Locomotive 3-ton truck, Fig. 67, in which the same motor is employed as on the taxicab made by the same manufacturers. This motor is of the standard four-cylinder, four-cycle, vertical type and is equipped with a governor. When adapted to cab use, the governor is set so that the motor cannot exceed the very moderate speed of 850 r. p. m. At this rate, it develops 16 horse-

Fig. 67. Chassis of Alco 3-Ton Truck.

power and limits the speed of the vehicle to 20 miles an hour. On the truck, it is set for 1,000 r. p. m., giving an output of 24 horse-power and a speed of approximately 12 to 14 miles an hour. The motor is mounted directly under the footboards, and as the height of the frame when the car is loaded is 36 inches above the ground, this makes every part of the mechanism of the power-plant directly accessible. As shown in Fig. 68, the radiator is spring supported, the helical springs on the upper and lower ends of the rods counteracting

one another and entirely relieving it of the jolting and vibration which is unavoidable in a heavily loaded vehicle running on solid tires. The usual sliding type of change-speed gear, providing three forward

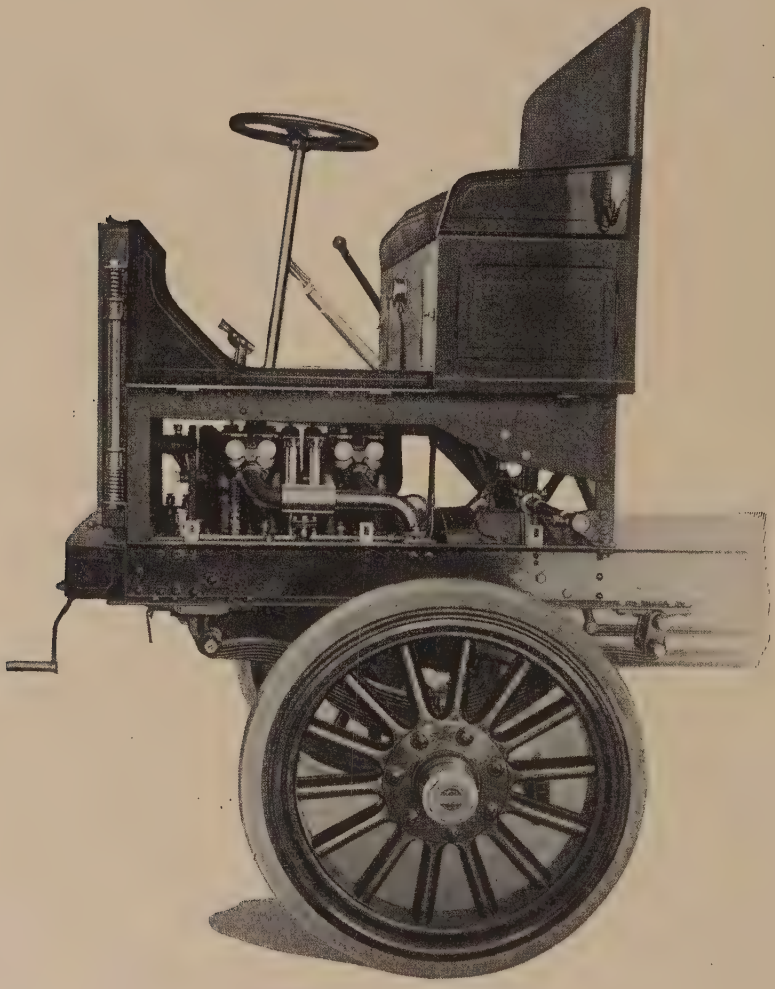


Fig. 68. Alco Truck, Showing Spring-Supported Radiator.

speeds and reverse, is encased in the same housing with the differential on a heavy countershaft, from which the drive is by side chains to the rear wheels. Solid one-piece axles of rectangular section are employed, the wheels running on Timken roller bearings. Straight

semi-elliptic springs are used for the suspension at all four points. The length of the loading space is 12 feet with the standard body, the width being optional. Though of the most substantial construction throughout, the American Locomotive truck has an unusually high-load efficiency percentage, as the chassis weighs but 4,850 pounds, the weight of the 3-ton truck complete with the usual standard express body having a light frame and canvas top, being 5,260 pounds. It will be noted that while the loading space is as great as that provided in many of the 3-ton to 5-ton trucks already described, the wheel base is very short—but 110 inches, owing to the placing of the motor under the footboards, which eliminates the necessity for any overhang forward. The maximum width is approximately 78 inches over the rear hubs, this corresponding to a gauge of 66 inches, which is about the standard in trucks of this size and ranging down to 56 inches in delivery wagons.

If a resumé of the features of the various types of trucks already described were made, it would be found that, while all vary to a greater or less extent, the designer has, in every case, attempted to incorporate certain well-defined standards. These are summarized by the manufacturers of the Sampson trucks as follows:

I. Accessibility and interchangeability of all parts.
II. Engine and change-gear units must be unaffected by any distortion of the main frame.
III. Units should be so connected that any possible movement relative to each other is provided for.
IV. All bearing and working parts should be extra large, and thoroughly protected from dirt and moisture.
V. Brakes should be large and powerful, with provision for quick and easy adjustment.
VI. Lubrication should be most thorough and entirely automatic.
VII. All parts should be easily accessible for inspection and adjustment.
VIII. The greatest strength must be given every part, consistent with the avoidance of unnecessary weight.

Sampson. The engine of the Sampson truck, Fig. 69, is of the standard four-cylinder, vertical, four-cycle type, and is designed to give its rated output of 40 horse-power at a normal speed of 925 r. p. m., or a piston speed of 850 feet per minute, which the builders consider to be the limit for good practice in commercial work. Oil is delivered under pressure by a gear-driven pump to the main bearings, from which it is distributed by centrifugal force to the

Fig. 69. Sampson 40-H. P. Truck.

BAKER ELECTRIC MODEL X HALF-TON WAGON

The Baker Motor Vehicle Company, Cleveland, Ohio

crank pins; the pistons, wrist pins, and cam-shaft bearings being lubricated by splash. The valves and all bearings are of unusually ample proportions. The motor is located under the footboards and is mounted on a subframe, suspended at the rear from the main frame by flexible plates, and at the front by compensating springs of proper tension, thus relieving it of all strains caused by the twisting of the main frame when the vehicle is traveling over rough surfaces, and at the same time effectively cushioning it against the heavy shocks transmitted to the main frame by the stiff springs necessary to carry large loads. The gear-box unit, including the differential and service brake, is hung from the main frame by three spherically seated bearings, a single one forward being universally swung from a cross channel member, while the other two are riveted to the main-frame side members at the driving-sprocket pinions, thus, giving a flexible three-point support.

The radiator—of the vertical, gilled-tube type—is of very large capacity, the circulation being effected on the thermo-siphon principle, thus dispensing with a pump. It is designed especially for commercial service, being composed of a center containing the tubes and tube sheets, and with cast aluminum headers and sides. A spring mounting is employed in connection with spherical joints at the top, thus preventing any strain from being transmitted to it by the frame. In case of accidental damage, its mounting is so simple that it may be removed and a new radiator substituted in a few minutes.

The clutch is of the conical type using large cork inserts and having a balanced thrust. It is connected with the gear box by means of a shaft equipped with universals of the box type, and normally transmits the power of the engine in a direct line. The gear-set is of the sliding type with selective operation, giving four forward speeds and one reverse, and at the normal motor speed stated, is designed to give the vehicle speeds of $2\frac{1}{2}$, 5, $7\frac{1}{2}$, and 11 miles an hour for the 4-ton and 5-ton trucks, and speeds of 4, $8\frac{1}{4}$, 12, and 18 miles an hour, when fitted as buses.

Final drive is by heavy roller chains from the side shafts of the balance gear to sprockets bolted to and centered by the rear wheel hubs. A feature of the Samspon trucks is the use of a dust- and oil-tight housing, Fig. 70, which also acts as a distance member for the

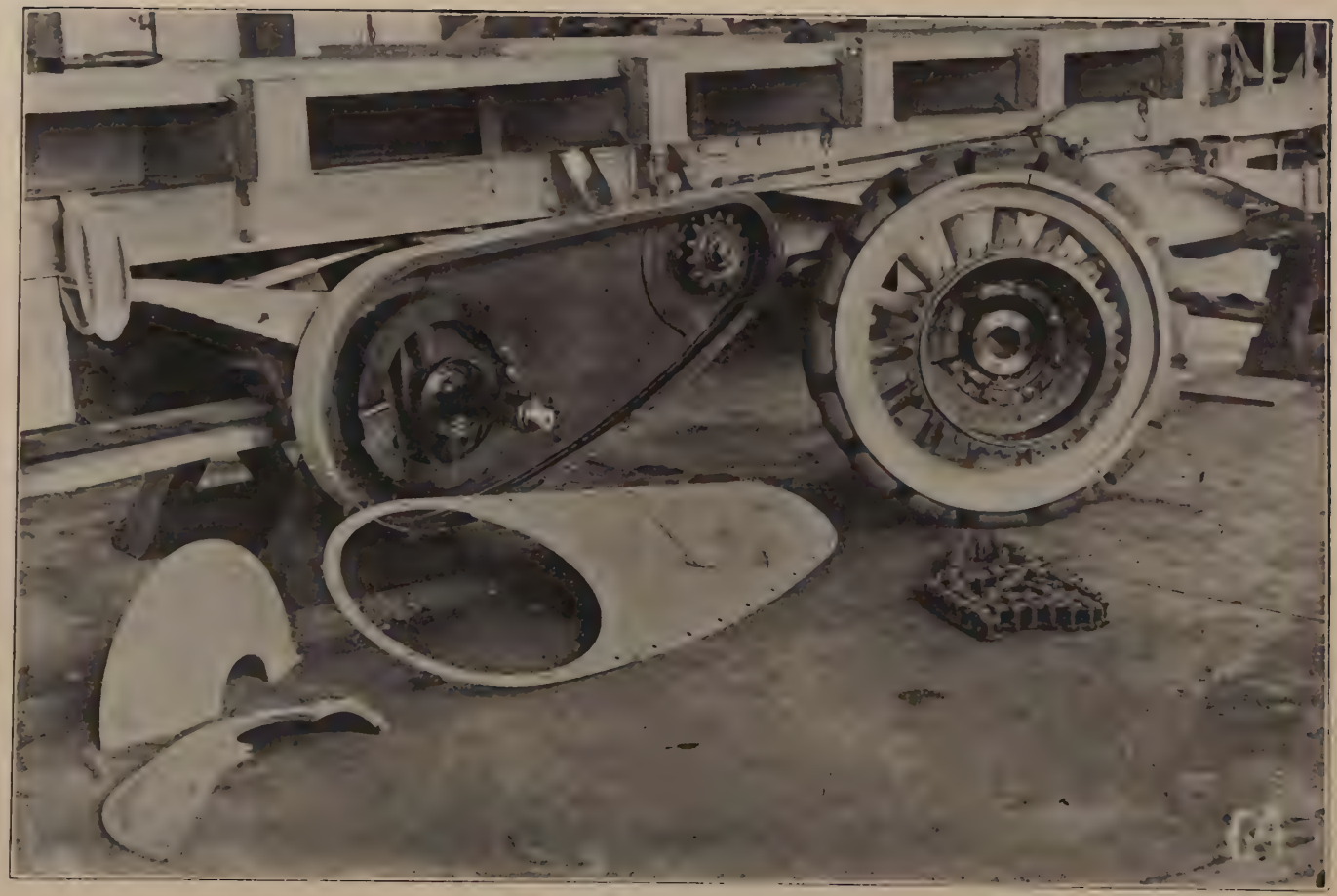


Fig. 70. Chain Housing on Sampson Truck.

rear axle, besides taking up the torque of the hub brakes on the driving wheels. The frame of the case consists of a substantial steel member of elliptical form, the sides being composed of light sheet steel. The entire case is hung on a spherical joint at the forward end and is hinged at the rear, thus relieving it of all strains. A simple and very accessible eccentric chain adjustment is provided to take up wear, the cases being provided with instantly removable covers which expose the entire chain and its adjustment. What this provision means in the added life and efficiency of the driving chains can only be appreciated by the condition of the outside of the chain cases, Fig. 71, after the vehicle has done a few hours' work on a muddy road. The life of an enclosed chain is several times that of one exposed to the mud and water, while the uniform and ample lubricant provided assures a high percentage of efficiency.

Hewitt. The Hewitt trucks are excellent examples of the result of long study devoted to the design of commercial vehicles of the heaviest types, as they are built in 5-ton and 10-ton sizes, and were probably the first of the latter capacity to achieve a commercial success in this country. The manner in which automobile practice has been modified throughout their design to meet the requirements of the transportation of heavy loads on a very economical basis, will be apparent from the following description: Ability to perform constant service of the most severe nature was adopted as the basis of the motor design, and it was constructed throughout with a view to standing up for long periods under the hardest kind of work. The bearings—which have always proved a source of weakness in commercial motors—designed after pleasure-car specifications, were increased in size considerably beyond any standard previously adopted for this essential. In fact, while the motor, Fig. 72, follows the usual automobile lines where compactness is concerned, it is really based upon stationary engine standards except where speed is concerned. The cylinder dimensions are $4\frac{1}{4}$-inch bore by $5\frac{1}{2}$-inch stroke, while the motor shows 36 horse-power at 1,000 r. p. m. Pistons and connecting rods are made of unusual length, in order to reduce the side thrust on the cylinder walls, a striking feature of the accessibility of the design being found in the fact that the pistons are readily removable through the side plates of the crank case by merely disconnecting. This permits of inspection and repair to any one of

Fig. 71. Sampson Chain Case, Showing Its Value on a Muddy Road.

the pistons, without the necessity of dismantling the motor altogether, Fig. 73. Such a repair would ordinarily involve placing the truck out of commission for two or three days—an expensive item of maintenance with such a heavy vehicle.

Extra large, flat-seated valves are employed and an unusual volume of water is provided for in the jackets. The crank shaft is cut from a solid slab of steel and the cam shaft is a one-piece drop-forging. Oiling is entirely automatic, by means of a force-feed oil pump driven through gears from the cam shaft, while ignition

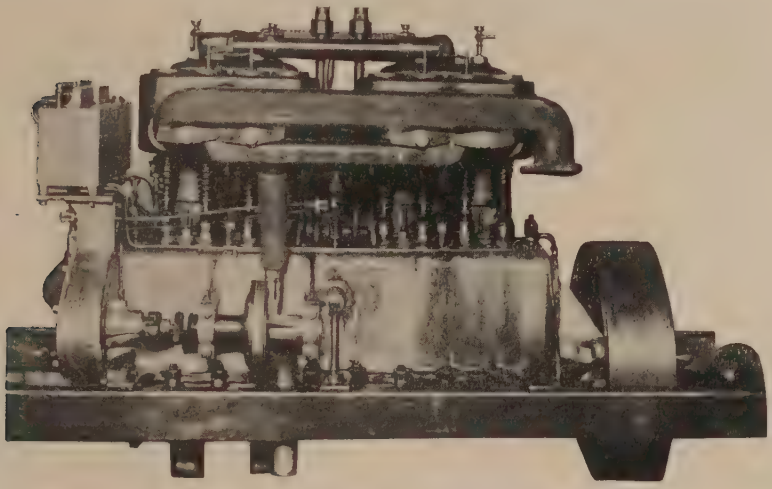


Fig. 72. Valve Side, Hewitt 5- and 10-Ton Truck Motor.

is provided for by Bosch high-tension magneto running with a fixed spark. As already mentioned, the magneto itself is an independent, self-contained system, and, on the Hewitt truck, it is mounted so as to be removable in a few minutes, the designer being of the opinion that a second magneto carried in the tool box provides the best form of emergency equipment.

The same feature of interchangeability is carried out in the case of the radiator. This is of the Livingston cellular type and provides an unusually large cooling surface. As heavy trucks are subject to extremely severe vibration and jolting when running light, a special form of mounting has been adopted. The entire radiator is set in a steel case, surrounded by felt, and the case itself is suspended on compensating springs so as to relieve it of all jar. In case

of accident, the entire radiator may be removed from the car and another substituted in a few minutes. A planetary type of change-speed gear of special form is employed, the method of control being one of the features of the Hewitt trucks. This control takes the form of three pedals, so that the driver is never called upon to remove his hands from the steering wheel. These pedals give the first, second, and reverse speeds respectively, and are so arranged that when one

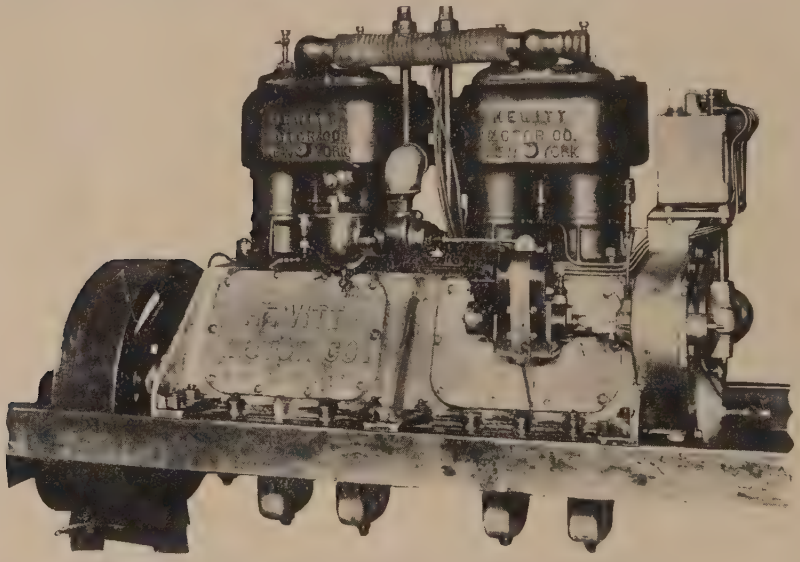


Fig. 73. Magneto Side Hewitt Motor Showing High Crank Case.

is pushed into engagement it locks there. By a special system of interlocking, pushing a second pedal automatically releases the first before the speed controlled by the second can be engaged, which makes the handling of a heavy truck extremely simple and easy. The truck is geared to make a speed of 8.6 miles an hour with the motor running at 1,000 r. p. m. 7 miles to 9 miles per hour is the most economic speed of operation loaded, while 10 miles an hour is a possible speed with an empty truck. Carrying a 5-ton load, the car is capable of running 4 to 6 miles on a gallon of gasoline and is capable of mounting grades up to 10 per cent with full load, Fig. 74

Hewitt 10-Ton. Contrary to general opinion, the chief difficulty experienced in the design of a truck to carry a load of 10 tons was not encountered in the motor or other parts of the mechanism,

but in the provision of a tire that would give satisfactory service under this very heavy load, as with the weight of the car added, the pressure on the ground reaches 700 pounds per square inch. A tire formed of heavy rubber blocks, the construction of which is gone into more in detail under the subject of tires, was found to solve the problem. The motor is the same as that used on the 5-ton truck, but the speed of the vehicle has been reduced to a maximum of 6 to 7 miles an hour as this is as fast as it has been found safe to travel with such a great weight. In a truck of this size, the parts are naturally of massive dimensions, Fig. 75. For instance, the frame is of pressed steel, having side members 9 inches deep, while the clear loading space

Fig. 74. Hewitt 5-Ton Truck.

back of the driver's seat is 14 feet. The heaviest chains of 2-inch pitch are employed for driving the rear wheels, while roller bearings of special design were found to be necessary to carry the load imposed on them. The driving sprockets on the rear wheels are 36 inches in diameter. As is the case on the 5-ton truck, the special, two-speed, planetary gear with pedal control is employed. This runs in oil, the low and reverse speeds being operated by asbestos faced bands, while the direct drive is obtained by engaging a conical clutch. This is held in position by a plate, acting on a set of springs which give just the necessary pressure to drive the car, so that the clutch cannot grip suddenly. The supply of oil in the gearset is maintained by the same oil pump which feeds the crank case of the motor. In this, as well as other features, the specifications of the 5-ton and 10-

Fig. 75. Hewitt 10-Ton Truck.

ton trucks are the same. It is naturally out of the question to give trucks of this character a large overload capacity, as a number of the parts, such as the wheels, chains, tires, and the like must be worked up close to their safe limit in the original design, so that carrying a continuous overload would be apt to destroy their factor of safety in a comparatively short time. However, it has been found within the capacity of a 5-ton truck to haul a 5-ton trailer behind it, in addition to transporting its own full load, giving it a total capacity of 10 tons. Such trucks are specially designed for the carrying of coal, building materials, structural iron, and other heavy products which may be transported in bulk. This company also builds 2-ton and 3-ton trucks of the same general characteristics.

Two-Cycle Types of Trucks. *Reliance.* Mention has already been made of the fact that comparatively little attention has been devoted to the development of the two-cycle motor for commercial use, and this is particularly true where the heavier types of truck are concerned. So far as the writer knows, the only large truck of this type on the market at the present writing is the Reliance, which is listed by its makers up to 5-tons capacity. In this size, it is equipped with a four-cylinder, two-cycle motor of the valveless or three-port type, the dimensions of which are $5\frac{1}{8}$-inch bore by 5-inch stroke, rated at 60 horse-power. This motor has been developed especially for commercial service and has numerous features of merit, one in particular being the possibility of adjusting the main crank-shaft bearings from the outside of the case, while the connecting-rod bearings may be reached simply by removing a plate from the bottom of the crank case. As the only moving part protruding from the crank case is the crank shaft itself, the motor accessories are driven directly from it at the forward end. The drive takes the form of a spiral gear meshing with a pinion on a vertical shaft which is directly attached to the gear pump below. This shaft also carries the timer at its upper end and drives the force-feed oiler by means of gear attached to it at a point where the shaft passes directly through the oiler, thus making this part of the motor quite as compact and self-contained as the remainder, Fig. 76.

The radiator is of the honeycomb type and is supported on rubber cushions in a steel channel case. The latter is held by means of ball and socket joints, so that no torsional strains can be trans-

mitted to it, while no bolts or studs are attached directly to the radiator, which may be removed from the casing in a few minutes. Ignition is by means of a four-unit coil and timer, supplied with current by two sets of storage batteries. The carbureter is of the conventional float-feed type with automatic auxiliary air intake such as is commonly employed on four-cycle motors, and is attached to a manifold communicating with the third port of each cylinder. When the latter

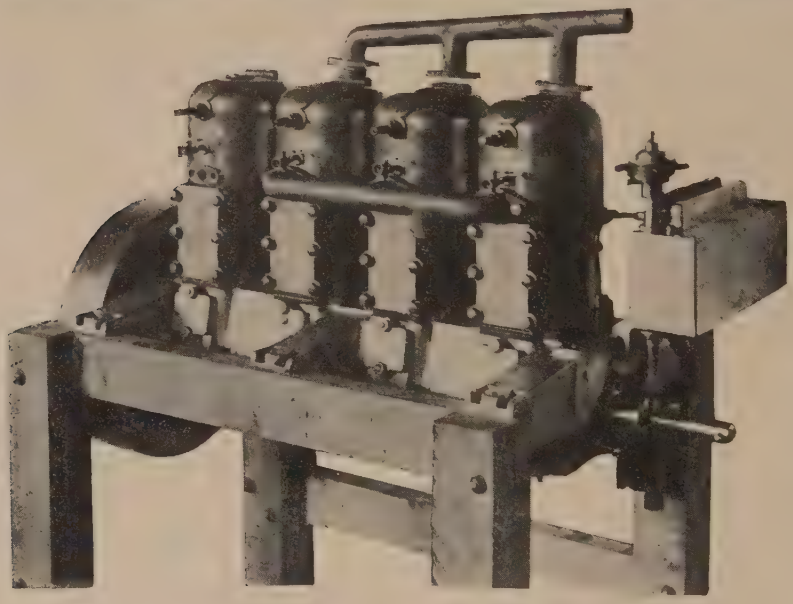


Fig. 76. Reliance Four-Cylinder, Two-Cycle, Truck Motor.

is uncovered by the piston on its upward stroke, a charge of gas exceeding in volume the capacity of the combustion chamber of the cylinder, is drawn into the crank case. On the following downward stroke of the piston, which, of course, is a power stroke, the fresh charge is compressed in the crank case, and when the piston reaches the lower limit of its stroke, it uncovers another port and the charge is quickly transferred to above the piston.

The clutch is of the standard conical, leather-faced type of the simplest form and it is disengaged automatically by the application of either brake. The gearset is carried in the same housing, but separated by a partition from the differential and bevel drive of the countershaft. It is connected with the clutch by means of a short

shaft and universals. The gearset itself is of the progressive sliding type, providing three speeds forward and reverse. The shafts are carried on annular ball bearings; the differential is of a special type and has its shafts mounted on adjustable roller bearings. A three-point support is employed to carry the transmission case, which is of cast iron. In the design of the remainder of the Reliance truck, conventional lines have been closely followed. As is the case with any of the trucks employing a double, side-chain drive, the speed of the vehicle may be altered to suit the conditions simply by changing the size of the forward, or driving sprockets.

What Future Developments May Be. In the foregoing, no attempt has been made to cover the entire field of American commercial car design of the gasoline type, but merely to cite a number of representative examples to illustrate the present trend in practice in what is admittedly one of the most important branches of the automobile industry. But in a work of this nature, it is quite as important to attempt to look beyond the present as it is to portray what has been done and what is now considered to be the highest type of achievement in this field.

Electric Transmission. It will be generally conceded by engineers that while the sliding type of change-speed gear has been successfully developed to a high degree of efficiency and dependability in spite of great obstacles, it leaves much to be desired. With improvements in material and design, it has survived despite its shortcomings, simply because nothing better has come to light. That it will continue to hold its place is at least open to question, for the transmission is a feature of such vital importance in connection with the internal combustion type of motor that attempts are constantly being made to improve it. Many of these have taken the form of an electric transmission of the power, and the details of the systems of this nature that have come into actual use are dealt with at length under "Gas-Electric Vehicles."

Manly Hydraulic Transmission. Another substitute for the gear drive is the Manly hydraulic, variable-speed transmission, in which a small hydraulic motor is directly connected to each driving wheel; thus all four wheels may be driven, instead of only two. The liquid—handled by a pressure pump which is run by the motor—is ordinary mineral oil of a low freezing point and low

viscosity, in order to insure free flowing qualities in all weather conditions. As the motor may be run at a constant speed, entirely independent of the rate of travel of the vehicle, its duty simply consists in subjecting the supply of oil to pressure. The minimum is about 200 pounds to the square inch, and the maximum 2,400 pounds, and, as might be expected, the system of valves and motors to properly handle such pressures, must be well designed and better constructed. The oil under pressure is admitted by a single lever directly to the hydraulic motors, which are connected to the driving wheels. This lever operates a special valve system giving the entire range of speeds ahead, as well as reverse.

A truck fitted with a transmission of this character was in service for a year, mostly in New York City streets, and carried a maximum load of 8,500 pounds. During that time, the machine covered a total of 3,000 miles over poor pavements and an examination of its condition at the end of that time revealed a further and particularly important advantage, viz, its tire economy. The speeds vary from a mere crawl to the maximum, and as starting is very easy and gradual, the tires are never subjected to the harsh treatment that is more or less unavoidable with the sliding gear.

In view of the manner in which the sliding gear has persisted, despite its detractors and all prophecies to the contrary, it would be rash to attempt to predict what the next decade may bring forth in the shape of an improvement. Whether the electric transmission can be developed to a point where the additional weight and higher initial cost will permit it to compete on almost equal terms with the mechanical type on medium weight vehicles is a question that the next few years should solve. From the experience with the Manly truck as well as from experiments along the same line that have been carried out abroad, it is evident that the hydraulic type of transmission is a future possibility.

COMMERCIAL VEHICLES

PART II

GASOLINE-DRIVEN TRACTION ENGINES

Under this head falls a type of machine that at first sight will doubtless strike the average reader as not coming within the category of the commercial vehicle at all. But it represents an extremely important branch that is just beginning to come into its own and which, in the course of the next ten years or so, is destined to prove a powerful factor in the elimination of the horse from many classes of work now entirely monopolized by animal traction. Haulage has formed but a comparatively small part of the work of the gasoline traction engine thus far, and doubtless represents a rôle in which it will not be generally used for some time to come; it is rather in the carrying out of purely agricultural operations on the large scale demanded by modern farming that it has shown itself to be of the greatest value.

Strange to relate, the idea of substituting the power of the internal combustion motor for that of the horse in farming operations was first advanced in countries where the need for it was least. On the extensive farms of the Western United States, horses are needed in such numbers to carry out the work that their value exceeds that of the machine which displaces them. The reverse of this, of course, is one of the greatest hindrances to "scrapping old equipment" and adopting a power vehicle of any kind. In France and England, however, where the gasoline-propelled tractor has been under development for several years, farms are small, though crops are larger in proportion. The United States has always led in the invention and manufacture of agricultural machinery, so that it was not long before attempts were made to apply the gasoline engine to this purpose. The value of machinery for such operations as plowing, harrowing, and seeding on a large scale, had long ago been recognized in

the adoption, to a limited extent, of steam traction engines, many of which are in use today. The disadvantages, however, of this form of power for farm use, especially in the West, had prevented its widespread adoption. The chief of these disadvantages was the expense for fuel as well as the difficulty of obtaining it in many sections of the country, while the low efficiency of the machine as a whole made its use impractical even with comparatively cheap liquid fuels, such as gasoline and kerosene.

The interest taken in agricultural tractors abroad will be manifest when it is recalled that an International, Agricultural-Motor Exhibition was held at Bourges, France—one of the most highly-developed agricultural districts in the world—in the fall of 1908. The chief competitors in the trials held were tractors of American, British, and French make, the last-named being of the type designed to haul the plows or other tools across the field by means of a drum and winding cable. This system had also been tried out in California and was seen to possess obvious disadvantages. It failed to score on the occasion in question, while the American tractor, true to the standing it has achieved the world over, easily carried off the honors. The machine in question was a tractor built by the International Harvester Company.

Tractors Follow Stationary Engine Practice. Tractors generally show more strongly than any other type of power vehicle now in use the influence of stationary engine practice. Students of automobile engineering will recall that the first attempts at automobile design in this country consisted of nothing more than the adaptation of the ordinary stationary engine to a running gear, and further that it was the dogged adherence to this abortive combination that did so much to keep the American automobile so far behind its European competitors in the first years of the last decade.

As a matter of fact, the majority of present day gasoline- or kerosene-driven agricultural tractors are little more than stationary engines of the horizontal type, mounted on a running gear suited to the needs of the machine. It does not follow from this that the design is a poor one for the purpose, as was the case with the automobile, as the conditions of service are totally different. Speeds are necessarily very low, as plows or other tools could not be handled properly at a rate of travel in excess of a few miles an hour, while weight is a

desideratum, rather than otherwise, in order to obtain the tremendous tractive power needed to start and haul loads involving such a great drawbar pull as is required to break a number of furrows in hard soil. As the loads are heavy and operation is continuous, economy must be considered, and the slow-speed, long-stroke, one- and two-cylinder engines employed are best adapted for this purpose.

International. The International tractor mentioned is practically nothing more than one of the stationary engines of this make, mounted on the platform of a heavy, four-wheel truck, Fig. 77. It may appear superfluous to mention that the latter has four wheels, until it is added that several types of tractors employ but three, in

Fig. 77. Gang Plow with Gasoline Motor Tractor in Heavy Soil.

which 80 to 90 per cent of the weight of the machine is centered over the driving wheels, the third wheel merely acting as a guide. The engine in question is of the long-stroke type with the valves in the head, the exhaust valve being mechanically operated, while the inlet valve is automatic; the governor, as is customary in stationary practice, is of the hit-and-miss type acting on the exhaust valve. In governors of this class, centrifugal force is taken advantage of to make the exhaust valve rod hit or miss the valve tappet, opening the latter or allowing it to remain open, according to the speed and the requirements of the load. As the automatic inlet valve depends upon atmospheric pressure for its operation, it cannot open unless the exhaust

valve has closed on the stroke just preceding, so that no fuel enters the combustion chamber except when an explosion is necessary. As the governor is also usually designed to trip the igniter mechanism out of action at the same time, such engines are very economical of both fuel and electric current. The cylinder is of large bore and a low compression is employed as compared with automobile motor practice, two huge flywheels being utilized to give the engine a smooth running balance. It is cooled by means of a modified form of water tank, placed forward. This is provided with a large, wire gauze screen with sloping sides, over which the hot water is sprayed immediately on leaving the water jacket, then is collected in the tank below and circulated.

The engine is mounted on a heavy channel iron frame, to which is bolted the subframe carrying the stub axle brackets. The front axle is arched and well trussed, and is provided with a ball-and-socket connection. The stub axles at the rear fit into heavy axle brackets. The drive wheels are entirely of metal, having 56-inch diameter and an 18-inch face; they have heavy lugs bolted to the tires to provide ample traction, even on soft ground. Two friction clutches are employed, a large one for the forward speeds and a smaller one for the reverse. The drive is through two sets of pinions and large gears, a sliding pinion on the crank shaft of the engine driving a large differential gear on a countershaft carrying two pinions at its outer ends, which engage large gears on the road wheels. The forward clutch has three shoes, with large friction blocks which engage the surface of a drum or pulley. Reverse is obtained by shifting a lever, which throws the large clutch out of engagement, and engages the small one, which drives an intermediate gear. The same lever gives both the forward and reverse speeds, while a foot lever applies a band brake operating on the differential. Steering is accomplished by means of a hand wheel, worm gear, and chains attached at two points to the forward axle.

The foregoing serves to describe the small-size International tractor, which is fitted with a 15-horse-power, single-cylinder engine, though it also generally covers the construction of the larger sizes, which have a 20-horse-power engine of the same type, with driving wheels of 64 and 70 inches in diameter, the gear drive also being somewhat modified to meet the requirements of the heavier machines.

The largest size is equipped with a friction reverse which may be engaged while the machine is moving forward without danger of stripping gears.

Abenaque. Tractors such as those described are designed principally for use on level land, or where gradients are very easy, such as are found on the large farms of the Middle and West. The Abenaque is a machine that has been developed for the hilly regions of New England. The engine is of the horizontal type usually employed for stationary and portable service, but is equipped with a special cooling device, consisting of two narrow steel tanks, mounted directly on it.

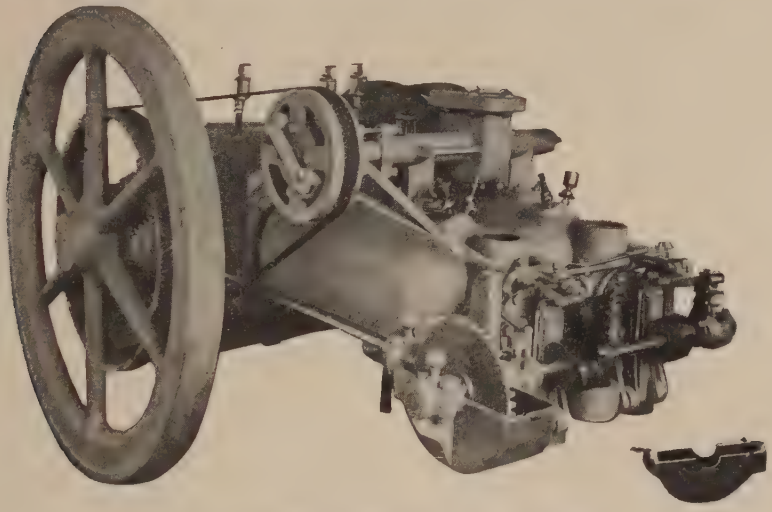


Fig. 78. Motor of Hart-Parr Traction Engine.

This makes possible the use of a greatly reduced quantity of water, while the head thus available assures a good circulation on the thermo-siphon principle. As they have been designed for hill and bad road work, these traction engines are equipped with three gear changes, giving forward speeds of one, two, and three miles per hour, and a reverse, all controlled by a single lever, the arrangement of gear changes being on the selective principle now almost universal on the automobile. The clutch is operated by a pedal, or long foot lever, and is of the type recognized as standard on hoisting engines. In appearance, the Abenaque tractor does not differ materially from the usual portable gasoline engine mounted on a wheeled platform.

Hart-Parr. The Hart-Parr tractor which has achieved considerable success, was one of the first to depart from the practice of employing the ordinary stationary engine as its motive power. As will be seen from the illustration, Fig. 78, the engine is of the two-cylinder horizontal type, the cylinders being placed alongside of one another, and having all the valve mechanism in the head, thereby making it very accessible. The crank shaft has the two throws placed 180 degrees apart, so that the heavy pistons are always moving in opposite directions. This gives an excellent mechanical balance and accounts for the single flywheel of greatly reduced size. The

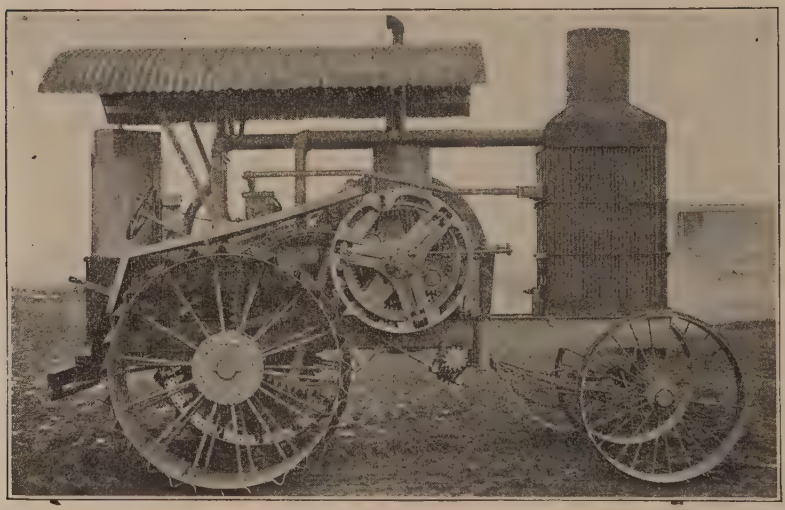


Fig. 79. Hart-Parr Traction Engine.

entire engine is enclosed, as in automobile practice, thus excluding dust and grit which is frequently present in large quantities in the service for which these machines are employed. It is lubricated by splash in the crank case, fed by two force-feed oilers. The use of an auxiliary exhaust valve, or port, uncovered by the piston just before the end of its outward travel on the power stroke, is also a feature of this engine that insures cool running under the heaviest loads.

An original and ingenious system of oil-cooling is employed, making it unnecessary to take any precautions to prevent freezing in cold weather. As will be seen from the illustration of the complete Hart-Parr machine, Fig. 79, this consists of a special type of radiator

mounted on the forward end of the platform. This radiator is formed of a number of thin corrugated sections, covered by a conical hood and a short stack. The supply of oil is circulated through these sections of the radiator and through the jackets of the cylinders by means of a centrifugal pump mounted directly on one of the cylinders. The exhaust from the engine is led into the hood over the radiator, and in the upper faces of the exhaust pipes under the hood are drilled a large number of small holes, causing the exhaust gases to be discharged upward in numerous fine jets, which not only act as a muffler, but also set up a strong draft of air through the radiator. As the oil

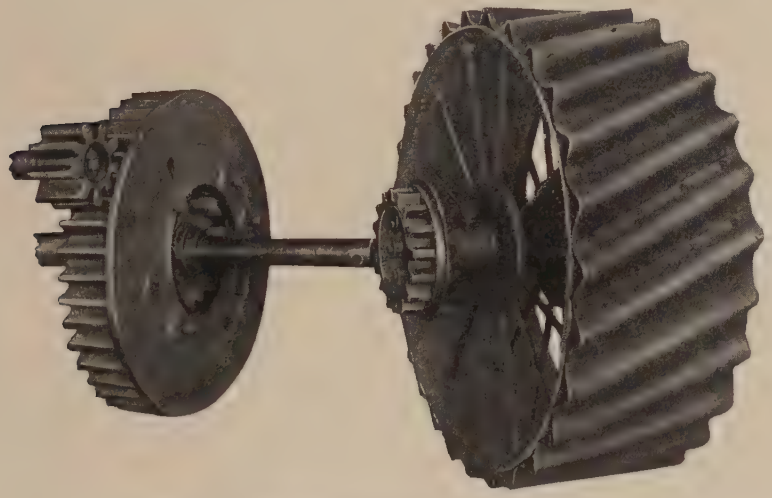


Fig. 80. Differential and Drive of Hart-Parr Tractor.

never reaches a temperature sufficiently high to boil it, and there is no waste, the original supply should last as long as the engine, barring accidents. The engine is capable of delivering 45 horsepower, according to the usual rating, but as the machine is intended to displace 22 draft horses, the tractor is given a nominal rating of the latter figure.

The driving wheels measure 66 inches in diameter and are driven through a train of gearing. Between the latter and the engine are interposed friction clutches of approved design, one being employed for the forward speeds and one for the reverse, both operating through a single lever; the traction gearing may also be independently

disengaged from the engine, the clutch operating lever then giving a forward or reverse motion to the power pulley for driving machinery. The reversing clutch is also utilized as a brake. For ordinary traction service, the Hart-Parr engines are geared for a speed of three miles an hour and are fitted with the usual bevel gear differential. The drawbar pull required for plowing is so heavy, however, that for this latter service, they are equipped with the substantial spur gear differential, shown in Fig. 80, and are geared for a speed of 2½ miles an hour.

To meet the demand for an engine capable of employing the lowest grades of fuel, the Hart-Parr tractors are also fitted to burn either kerosene or crude petroleum, this being a decided advantage in remote districts in the United States, and particularly in foreign countries, where gasoline is either prohibitive in price or not obtainable at all. These tractors can likewise burn alcohol by making a slight modification, and it is anticipated that this fuel will be largely used in farm work in the future, owing to the constant upward trend of the cost of all petroleum products and particularly gasoline, as influenced by the automobile demand. When using kerosene or crude oil, the engine is started with gasoline from cold, the tank being specially designed to carry in addition to the regular fuel supply, a small quantity of this fuel for starting. Two sizes of the Hart-Parr tractors are listed, the 22-horse-power size just described, and a smaller machine having a nominal rating of 17 horse-power. The latter weighs 7½ tons, while the former is one ton heavier, and the plowing engine of the higher power weighs 9½ tons. The bore and stroke are 9-inch by 13-inch in the 17-horse-power engine, and 10-inch by 15-inch in the larger size, the engines running at 280 and 300 r. p. m., respectively, and making 17.3 turns of the crank shaft to one revolution of the driving wheels. The experience of several years in the handling of a large number of engines employed in various capacities, shows that they will operate 10 hours per day doing the heaviest class of work on a fuel consumption of 25 to 40 gallons of kerosene or gasoline, according to size.

Avery. As will be noted by its general outline, the Avery tractor, Fig. 81, represents a close approach to automobile practice and is a total departure from the types previously described. It is, in fact, a type of commercial vehicle designed for farm use, and it

will be apparent from the following description of its construction that it is intended for a wide range of utility. The power plant consists of a four-cylinder, high-speed gasoline motor placed forward on the frame and under a bonnet, or hood, as is the case in the usual gasoline driven truck or pleasure car. Cylinder dimensions are $4\frac{3}{4}$-inch bore by 5-inch stroke, the motor itself being of the standard four-cylinder, vertical type. It is nominally rated at 12 horse-power, but shows a brake output of 36 horse-power. The engine auxiliaries are the same as employed in automobile usage, such as a float feed carbureter, high tension ignition by means of a magneto with storage battery in reserve, and cooling by pump circulation through honeycomb radiator, mounted as usual except that the frame forward has been narrowed to the width of the radiator itself.

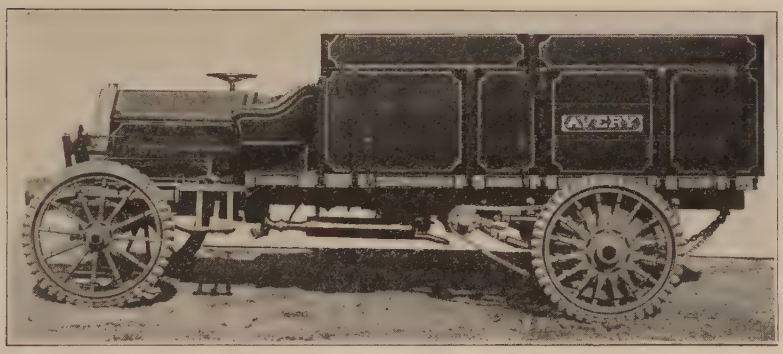


Fig. 81. Avery Tractor.

The power is transmitted through a standard type of sliding gear, operating on the selective principle and giving three forward speeds and one reverse. The differential is placed on a countershaft, final drive to the road wheels being by means of double side chains in accordance with the practice developed in chain-driven pleasure cars of high power. The usual distance rods are employed to bear the stresses of driving and to provide a means of adjusting the chains. Semi-elliptic flat springs are used forward, directly under the motor, to avoid road shocks, while heavier springs are used in the rear. Internal expanding brakes are fitted in drums on the driving wheels. The wheel base is 140 inches, and the wheels, $41\frac{1}{2}$ inches in diameter, giving the vehicle a speed of from 4 miles to 15 miles an hour.

Where desired for road service, four-inch, twin, solid rubber tires may be fitted on the rear and single tires of the same forward. As ordinarily supplied, the wheels are equipped with cast steel rims studded with two-inch hardwood plugs, which make a smooth-tired, silent running wheel which not only meets every requirement of farm service but is also practical on hard roads and paved streets. This makes a wheel of low initial cost as well as one that involves little or no expense for replacements and repairs, the hardwood plugs being very durable. In addition to the construction

Fig. 82. Brennan Tractor.

mentioned, the wheels are also provided with 8-inch extensions in the rear, giving the driving wheels a total face of 14 inches. These extension rims are fitted with nine blades which automatically act the moment the wheels strike soft ground. When this occurs, the blades slide and catch back, penetrating the ground to a depth of 4¼ inches, and effectively preventing slip. For work in the field or other soft land, they may be permanently locked in the outward position by a pin, provided for the purpose, or they may be detached altogether by removing a few bolts.

As a truck, the Avery tractor has a capacity of three tons and is also capable of hauling one or two loaded trailers behind it; in farm work it will plow eight to ten acres a day, using approximately

two gallons of gasoline per acre for ordinary plowing, and moving at a speed two-thirds faster than horses, from which its efficiency in this work, as compared with animal traction, may readily be gauged. For haulage, it may be fitted with bodies designed for the transportation of grain, stock, hay, or the usual stake body for general use, while a pulley attachment is also supplied for driving farm or other machinery.

Brennan. As a type falling between the two general classes

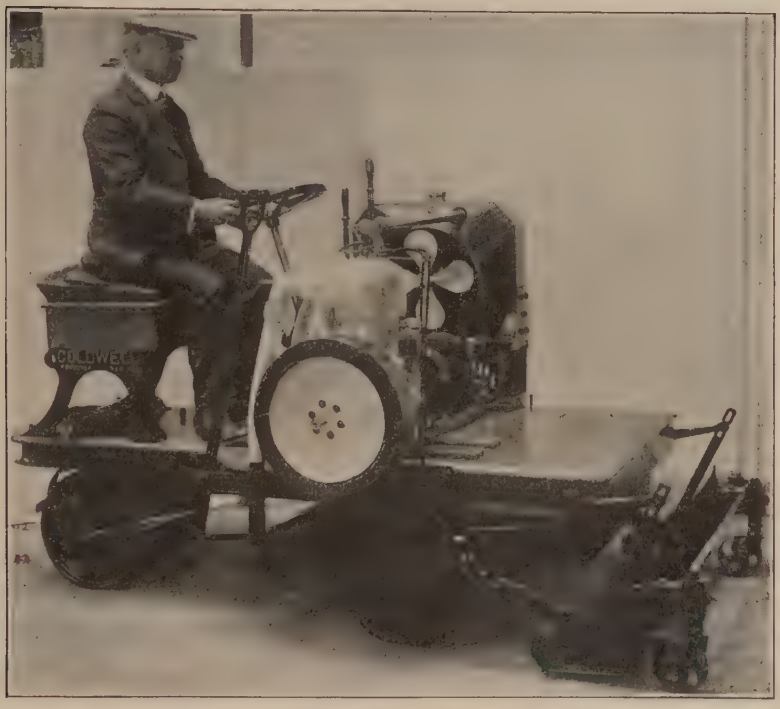


Fig. 83. Coldwell Gasoline-Driven Lawn Mower.

described above, may be mentioned the Brennan traction engine, shown in Fig. 82. This is a combination of the features to be found in the former, in that a four-cylinder, vertical, high-speed Brennan motor of the usual automobile type is employed as the power plant, while the construction of the running gear is similar to that of the usual heavy and very slow-moving traction engine. In fact, so far as the latter is concerned, it represents a closer approach to the old steam tractor type than any of those described.

Fig. 84. Avery Tractor Pulling a Gang Plow.

Fig. 85. Avery Tractor on the Road.

Kelly-Springfield. Though designed principally for road rolling, the Kelly-Springfield gasoline-driven road-roller may also be utilized as a traction engine for hauling road material, or for running stone crushers and similar machinery. As weight is an absolute essential in obtaining the maximum compression on the road material to be consolidated, the tractor is of the most substantial construction throughout and no attempt has been made to cut it down by the adoption of a high-speed engine, such as that employed on the Brennan tractor.

Coldwell. The Coldwell gasoline-driven lawn mower, Fig. 83, is a type that does not fall into any of the foregoing classes. Its motive power consists of a two-cylinder, four-cycle, vertical motor, placed transversely on a platform. The drive is through the medium of a planetary gear and a chain. The same makers also build lawn mowers with one- and two-cylinder, two-cycle motors.

Generally speaking, the types of vehicles already described suffice to complete the range of those ordinarily employed for agricultural and similar service, and from the accompanying illustrations one may gain an idea not only of the varied character of their usefulness in such operations as plowing, threshing, road-building, and haulage, but likewise the effective manner in which the work is performed at a greatly reduced cost. Fig. 84 illustrates an Avery tractor at work in the field, while Fig. 85 shows it on the road, carrying and hauling a load.

ROAD TRAINS FOR HEAVY HAULAGE

It will be apparent from a study of the design of both the electric and gasoline trucks that there is a more or less sharply defined limit to the capacity which these vehicles may not exceed and still be commercially practical. This is lower in the case of the electric than the gasoline truck, for obvious reasons, and the fact that the former has seldom been built to carry more than five tons would seem to place this figure as its permissible maximum. As a matter of fact, it is better adapted for carrying loads up to and including three tons, than above this weight. The gasoline truck is naturally not limited as to power, but, as has been pointed out, difficulty has been encountered in the design of a suitable tire for weights much in excess of five tons, and it will be noted that up to the present writing, but

one American manufacturer has attempted the design and construction of a 10-ton truck.

It is not difficult to realize that there are numerous reasons which make a load of ten tons about the maximum which can be practically transported on a commercial scale in a single vehicle, regardless of the type of power-plant employed to move it. The first of these reasons would naturally be the excessive dimensions of the body and wheel base necessary to accommodate a greater weight in the form of anything but the very heaviest classes of merchandise, and making the vehicle as a whole so unwieldy that it could not be handled in traffic. Not alone because of its enormous size, but likewise because of the excessive pressure per square inch to which its wheels would subject pavements, bridges, and manhole covers, it would undoubtedly be barred from using the streets in the average municipality. The amount invested in such a large unit would be considerable and the loss arising from having to withdraw it from service for repairs would be correspondingly heavy. For this reason it will be seen that there are other matters beside those of design which operate to restrict the size of a vehicle. Many manufacturers have not considered the building of trucks above 5-ton capacity commercially practical, as whenever large quantities of heavy merchandise are to be transported, it is preferable, for the reasons cited, to move it in units not exceeding this size, rather than to attempt to carry greater amounts at one time. On the other hand, the investment involved in the purchase and the expense of maintenance of a number of such trucks would frequently be so large as to be unjustifiable for the transportation of comparatively cheap material. Sand, bricks, iron ore, low-bearing gold ore, and similar materials may be cited as instances.

The road train solves the difficulties mentioned above in a satisfactory way. A horse that is only capable of carrying a few hundred pounds on its back, can haul many times that load in a wagon; and so too a 5-ton truck is able not only to carry its own load, but haul a trailer bearing an equal weight at the same time. Practically the only difference in such a case would be the amount of fuel required and the slower speed at which the double load could be moved. To go back to the single large truck for a moment, another objection is to be found in its inability to exert sufficient tractive effort under all

conditions of loading and road surface. One expedient adopted to overcome this has taken the form of a four-wheel drive, examples of which have been given on Page 37 and Page 123. But this necessitates expensive complication of the propelling and steering mechanism, with the extra weight of these parts assisting depreciation. To overcome these disadvantages, six-wheeled vehicles have been tried, but it will be evident that unless more than one pair of wheels is driven, the traction disadvantages of the ordinary two-wheel drive are always present, and the six-wheelers in question have always been designed to utilize the third pair as the drivers, with most of the dead load borne by the other four. The complication, inseparable from this arrangement, detracts seriously from its commercial practicability, not to mention the greatly increased initial cost and expense for maintenance. It is therefore doubtful if the six-wheel vehicle will ever be seen in any great numbers.

The numerous difficulties to be overcome would appear to make the traction engine and trailers, the only practical solution of the problem. To an extent, this method is employed in the United States with the old style steam tractors as the motive power, but in the light of modern developments, the speeds attainable by this method are too slow. In England and on the Continent, where speed does not appear to be quite as much of an object as in this country, tractors have been largely employed From an engineering point of view, the objectionable feature of having but a single pair of driving wheels, counts seriously against the system. Only the fact that roads are very much better abroad than in this country has made its adoption on any scale commercially possible. Here, unless the driving wheels were fitted with cleats to assist propulsion, it would be impossible, at times, to haul a paying load at all, and even with cleats this could not be done if the road had deep sand or mud on it. The use of cleats or similar traction devices is objectionable in road work, because they concentrate the load of the driving wheels on comparatively small areas of the road surface, causing rapid deterioration.

Renard System. The first practical attempt to eliminate the shortcomings of the ordinary traction system was made by Colonel Renard, who developed the road-train system which bears his name. This consists of several vehicles coupled together, the first one of which carries the power-generating, speed controlling, and steering

apparatus. A shaft, arranged with the proper number of universal and slip joints extends throughout the length of the train and transmits the power for propulsion to the driving wheels of each vehicle. It is accordingly possible to transport a large and well-paying load without having excessively heavy individual units, which are subject to rapid depreciation due to the inability to provide sufficiently resilient tires, or sufficiently strong wheels or springs for heavy loads. The road surface is also protected as the distribution of the weight over the greater number of wheels and, therefore, on a correspondingly greater area, does not make the unit load any heavier than where a single vehicle is employed. In addition, rubber tires are not necessary as sufficient tractive effort is obtained by the increased number of propelling members. Steel tires may be used on the trailers, since they carry no mechanism other than the comparatively simple driving and steering apparatus mounted on them, while rubber tires are permissible on the leader, or power-wagon, because in no case would it be found necessary to have the weight of this exceed what has been found practicable in independent units, in fact, it need not be above 3 to 4 tons.

The chief disadvantage of the Renard system lies in the application of power throughout the train by mechanical methods. This involves the employment of a large number of universal joints, and it is a matter of common knowledge that their efficiency is directly proportional to the angle at which they must transmit the power. Owing to variation in the road surface, this would always be considerable even where the train was moving straight ahead, reaching a maximum in rounding curves of short radius. In other words, much too large a fraction of the total power developed by the leading vehicle is wasted in the linkage between it and the driving wheels of the various trailers; the actual driving mechanism of the latter also contributes to the power loss in a greater degree than where electricity is employed for this purpose.

Sampson Train. These considerations led to the construction of the Sampson motor road train, which was exhibited for the first time two years ago at the automobile show in New York. Though designed along the same general lines as the Renard train, it really combines engineering features that are the outgrowth of motor-car and electric-railway practice. Its chief advantage naturally lies in

the employment of electricity as the motive power, owing to its far greater flexibility. It is, in brief, a Renard train with a multiple-unit, electric control system, such as is now employed on thousands of elevated and subway trains in urban railway service. On the usual type of gasoline truck, 40-horse-power is not considered more than sufficient to move a load of 3 to 5 tons, and many vehicles of the latter capacity are equipped with 60-horse-power motors. In the Sampson road train, a 40-horse-power motor develops sufficient energy to transport 14 to 20 tons, according to the number of trailers employed. Every car is self-propelled, just as every other car in an elevated or underground train is a "motor car," the entire train being controlled by the motorman in the box of the first. But as the motor road train has no outside source of energy such as the third rail or trolley wire, each vehicle must derive its power from the tractor. It has already been pointed out how this is accomplished mechanically in the Renard train.

Motor. The source of power in the Sampson train is a four-cylinder, vertical, four-cycle gasoline motor of the type usually employed on the gasoline-driven truck, but instead of transmitting its power through numerous and constantly changing angles by positive mechanical means, perfect flexibility is attained by first converting it into electricity and transmitting this through heavily insulated cables to the motors on each of the trailers. The motor is accordingly coupled by means of a heavy, Morse silent type of chain to the armature shaft of a multipolar electric generator placed in front of it and directly behind the radiator. The voltage at which the current is supplied may be varied through a range which insures that the full current capacity of all the motors is within that of the generator. The current is controlled on the series-multiple system by a rotary switch interlocked with the starting rheostat so as to make it impossible for the driver of the train to accidentally damage any of the apparatus. This switch is operated by a second wheel mounted on the steering pillar, just below the steering wheel, which not only actuates the steering gear of the leading vehicle, but also that of all the trailers, causing their wheels to track almost exactly with those of the first car.

Switches are also provided so that the train may be hauled by the motors of the tractors alone; or one or more of the trailers may

be operated while the leading car is standing still. The power-plant, including the radiator, is mounted on a subframe, suspended from the main frame by springs, to relieve it from torsional stresses and to prevent damage from vibration and jolting due to the employment of steel tires. Each car has six wheels, the intermediate pair being of a larger diameter than the other four and acting as the drivers. They carry a predetermined proportion of the entire weight borne by the trailer and measure 54 inches in diameter; they are fitted with steel tires of a width to suit the conditions. Two independent electric motors on each car drive these wheels through a reduction gear. The motors are spring suspended and are particularly de-

Fig. 86. Sampson Power Wagon.

signed not only to stand heavy overloads, but also to be proof against the roughest kind of usage. They are back geared, through pinions running in an oil bath, to jack shafts carrying sprockets on their outer ends, from which the final drive is taken by means of $1\frac{3}{4}$-inch pitch roller chains. As each driving wheel is thus driven independently and is free to rotate at any speed imposed upon it by the conditions, regardless of the others, there is no need for differential gearing, while the electrical transmission of the power eliminates the usual

sliding change-speed gear and driving shafts. These driving wheels are fitted with cleats which are provided in order to secure ample traction with steel tires, and the suspension is of such design that the wheels may ride over all sorts of obstacles with impunity, as is well illustrated by Fig. 86.

Steering System. One of the features which makes the use of the Sampson train possible in the rough country in which it is designed to operate, is the inter-connected system of steering already touched upon. Though apparently very unwieldy, one of these 14-ton trains

Fig. 87. Sampson Road Train Making a Sharp Turn.

can negotiate a corner that is beyond the average touring car—in fact, even beyond the taxicab whose steering gear is specially designed with the requirements of city traffic in view. In fact, one of these heavy trains can easily get around a corner which was only possible for the six-foot-wheel-base runabouts of several years ago. The extremely sharp turns that can be negotiated are strikingly illustrated in Fig. 87, in which the tractor and the last trailer are going in almost diametrically opposite directions at the same time. When in New York a few years ago, the writer saw a train turn a corner in a narrow street with its wheels within six inches of the curb, while the wheels of the last trailer came less than two inches nearer to the curb at the same point.

LOZIER FIVE-TON GASOLINE MOTOR TRUCK

Lozier Motor Company, Detroit, Michigan

This result is obtained by not only utilizing the front and rear wheels of every one of the cars as steering wheels, and connecting the steering tongue of one car to the one preceding it, but also by cross-connecting the front and rear pairs of wheels of each vehicle, all being mounted on steering knuckles as in automobile practice. The connecting rods of the steering gear are equipped with universal joints and are supported at the center, the joints relieving the rods of the strains due to the changing positions of the front and rear axles as the car moves over uneven ground. The driver, sitting on the tractor, controls the whole train by means of the usual hand steering wheel and an irreversible gear connected with the front pair of steering knuckles of the tractor. By means of the cross-connecting rods underneath, the rear pair of wheels is turned in the opposite direction to the front pair through precisely the same angle, thus giving the entire car a pivotal motion on the central pair of driving wheels. This carries the rear end to the outside of the circle, so that the rear wheels, instead of cutting inside of the track of the forward ones, follow the same path.

The method of connecting the steering of the tractor with that of the trailers will be understood when it is borne in mind that all are "double-enders," *i. e.*, alike at both ends so far as the possibility of connecting them together is concerned. A yoke, bolted to the axle at the center is also fastened to the tie rod that connects the steering knuckle arms. In the slots at the ends of this yoke is bolted a forked steel tongue, in the free end of which is an eye, or hole. This fork is at the rear end of the tractor and by means of the eye and an eye-bolt it is connected to a similar fork protruding beyond the front end of the first trailer; this construction is similar in many respects to the old link-and-pin coupler of steam railway practice, except that the eye-bolt is clamped to a horizontal rod that is free to slide in a metal frame, bolted to the under side of the car, and the bolt to which the tongue is attached projects downward, through a slot in this frame, sufficiently to permit of considerable lateral movement. This motion is cushioned, however, by placing a coiled spring under compression at either side of the rod, to avoid the shocks that would otherwise be transmitted to the steering gear.

It will be readily understood that, owing to the opposite angles which the steering wheels of the tractor, or leading car, assume when

making a short turn, the rear end swings out as the front end swings in, exactly as when a long street car goes round a corner the front and rear trucks assume opposite angles. The outward swing carries the front end of the tongue of the trailer in the same direction it had been moving, up to a certain point, when it is suddenly deflected in the new direction. As the tongue moves, it changes the angles of the four steering wheels of the trailer. Thus, the front of the first trailer begins to make the turn at practically the same point as the tractor did, while the rear end swings outward, continuing the second trailer in the original direction. With this construction, the entire train, measuring 60 feet in length, can be turned in a circle having a radius of 20 feet, measured outside the hubs. The operation of steering is as easy as that of a 5 ton truck and the control is so simple that one man can operate the whole train with ease.

Drawbars are used between the trailers, their principal function being to equalize the distance between the several units of the train and to equalize traction. The torque is so evenly distributed throughout the train, however, that it has been found possible to walk between the trailers and pull out any one of the drawbar pins while the train was climbing a 11 per cent grade under load.

Brakes. Braking is effected electrically through the motors themselves under ordinary conditions by adjusting the controller at a point which provides a braking effort equivalent to the capacity of the motors. The electrical braking system operates smoothly and is easy to handle. For emergency purposes and for service in very hilly country, each of the driving wheels is equipped with a powerful, expanding-band brake operating against the face of the sprocket drum. Those on the tractor are set by means of a hand wheel just below the steering wheel, while those on the following cars are operated by a wheel attached to the side of the frame and must be manipulated by an assistant on the trailer. With the exception of these emergency brakes, the entire control of the train is concentrated in the hands of the driver, who rides on the tractor.

To facilitate making up the train and maneuvering in small yards or other confined spaces, both the tractor as well as all the trailers are made double-ended, and any of them can be connected up and run either end foremost with equal facility. Sockets, similar to those employed for charging electric vehicles, are provided at both

ends, into which plugs on the end of the connecting electric cables may be inserted. By using long connecting cables, the trailers may be moved about freely while the tractor itself is standing still. Although all the driving wheels are provided with cleat-equipped steel tires, solid rubber tires may be employed where the conditions are such as to warrant their use, though the steel-tire equipment has been found to provide all the tractive effort that is necessary.

The tractor itself, Fig. 88, has a carrying capacity of 2 to 3 tons, in addition to transporting the power plant, which is placed under a huge bonnet forward, as in automobile practice. Each trailer can carry 6 to 8 tons, the dimensions of the loading platforms

Fig. 88. Sampson Motor Road Train in Service.

being 17 feet by 4 feet 2 inches. The bodies are carried on four extra long, semi-elliptic springs, which are pivoted and guided in pedestals, giving them the functions of equalizing beams to distribute the load uniformly on the three axles, no matter how rough and uneven the road may be, and of maintaining the axles in correct transverse position, relative to the body. Distance rods hold the axles against fore and aft displacement, the ends of the springs merely resting in pockets on the axles and thus contributing greatly to the flexibility. A speed of six miles an hour can be attained on the level with a load of 20 tons, this being based on a hard macadam road. On level dirt roads, this would be reduced to 5 miles an hour, and to 2 miles on a ten per cent grade with a good road surface.

Gibbs Train. Another American road train was the Gibbs and while it is no longer built, so far as the writer is aware, its design is of interest, not alone as showing the tendency in this direction, but also because Gibbs trains have been in use in the West. The first Gibbs train consisted of a power wagon and two trailers, the motive power being a three-cylinder, vertical gasoline engine, direct connected to an electric generator furnishing power to motors on the trailers. These trailers were practically nothing more than heavy trucks built on lines that have become familiar through years of usage in wagon building. The front wheels was small, in order to turn under the body, while the rear ones were almost twice their size. In both cases, they were carried directly on the axle, and the entire front axle of each of the trailers was swiveled for the steering, instead of the wheels being mounted on steering knuckles, as has become standard practice in automobile design. They were interconnected so as to be steered from the tractor, but as only two wheels on each vehicle could be turned, the train was naturally not capable of rounding as sharp a turn as the Sampson train.

The tractor itself took the form of a road locomotive, being protected by a cab similar to those employed on electric locomotives, and was not designed to carry any part of the load. Its wheels were of comparatively small diameter and were shod with solid rubber tires, while those of the trailers were of steel. The speed of the train was regulated by a two-motor, railway type of controller so modified that by operating the drum intended for reversing the car motors, the vehicle motors would be connected in series or multiple combination. The motors themselves were of the standard series-wound type ordinarily employed in electric automobiles. The main drum of the controller was employed to cut resistance in or out of the motor circuit. No provision was made for reversing the trailers as they were only designed to run in one direction; separate switches on the tractor, however, made it possible to drive the latter in either direction.

The second Gibbs train consisted of a power wagon hauling four trailers, the former having as its power-plant two, three-cylinder, gasoline engines driving a double-commutator electric generator through positive clutches on the engine shafts and Morse silent chains. The rear wheels of all the trailers, which were four-wheelers,

were driven by series motors through reducing gearing and roller chains. The road wheels in this case were of special construction, consisting of steel disks flanged at the circumference. These disks were solidly riveted to bronze-bushed steel hubs and carried steel tires eight inches in width. Speed regulation was accomplished by the same type of electric controller employed on the first train, except that the controller drum generally used for reversing the car motors was in this case utilized to connect the two windings on the armature of the generator in series or parallel, while the main drum of the controller cut resistance in or out of the main motor circuit. Each vehicle had an independent switch for reversing the motors. This train was employed to transport machinery and supplies from the railroad station to a mine in Arizona, the trip being 115 miles each way, the route leading through a desert and mountainous country, entirely guiltless of roads according to the usually accepted definition of the term.

It is for service of this nature that the road train is particularly adapted and as there are many localities in this country and Mexico where the demand for transportation to and from mines situated at long distances from the railroad is active, but where the traffic would not warrant the building of a railway line for many years to come, there will doubtless be considerable need for heavy road trains of the gasoline-electric type. The question may doubtless occur to the thoughtful person why the ordinary heavy truck, say of 5-ton capacity, would not fill the requirements equally well, particularly as it would be capable of greater speed than the train. It will be recalled, however, that mention has been made of the fact that no more power is required to move 14 to 20 tons load on a train, than is needed to propel the average 3-ton to 5-ton truck, while under the extremely adverse road conditions found in districts where trains are now employed, the speed of the single vehicle would doubtless not exceed the average of the multiple unit. But the most important factor would be the increased cost of fuel and labor, as in the Far West and Southwest, fuel is one of the most expensive items. The labor cost would be increased in exactly the ratio that the number of independent units was added to, as in place of the single driver needed for a tractor and five trailers, five drivers would be required. By purchasing a second motor for the tractor, a second armature

for the generator, and adding a stock of such other replacement parts of the power-plant and mechanism of the vehicles as are most apt to give out in service, there is no reason why one of these road trains should not prove very efficient and reliable.

SPECIAL TYPES

Where both speed and ability to transport heavy loads with great rapidity are essential, the gasoline-propelled vehicle is naturally much the superior, not only of other types of power wagons, but also of the horse. The most important service in which these qualities may be utilized to the greatest advantage, is naturally that of fire protection, and a large number of automobiles of one type or another are in use for this purpose the country over. Those first adopted were naturally nothing more than touring cars, used to enable fire-department officials to arrive on the scene in advance, in order to most effectively direct the placing of the slower horse-drawn apparatus. Then came the addition to the touring car of the lighter forms of fire-fighting apparatus, such as chemical tanks and the like, and later in its order came the power-driven, chemical fire engine, which was nothing more or less than a high-powered, touring-car chassis fitted with the apparatus necessary to enable it to assume this rôle. In its turn there has been developed the fire patrol wagon, carrying the equipment needed to protect the contents of burning buildings, so that by successive stages every function of the fire-department service formerly carried out by horse-drawn apparatus, has been usurped by the power-driven vehicle. This process of development culminated a year or two ago by the ordering of a specially designed hose wagon for the new high-pressure service of the largest city in the country. The vehicle supplied, Fig. 89, was built by the makers of the Knox cars.

In every case, the chief difference between these special vehicles and the types of trucks already described lies mainly in their equipment, with certain modifications of the chassis to meet the changed conditions; it will, therefore, only be necessary to give a sufficiently detailed description to permit of the identification of the chassis as one of the types already previously dwelt upon. New York's special, high-pressure service wagon, has as its foundation a chassis of one of the Knox 8,000-pound trucks. This is equipped

Fig. 89. Knox High-Pressure Hose Wagon.

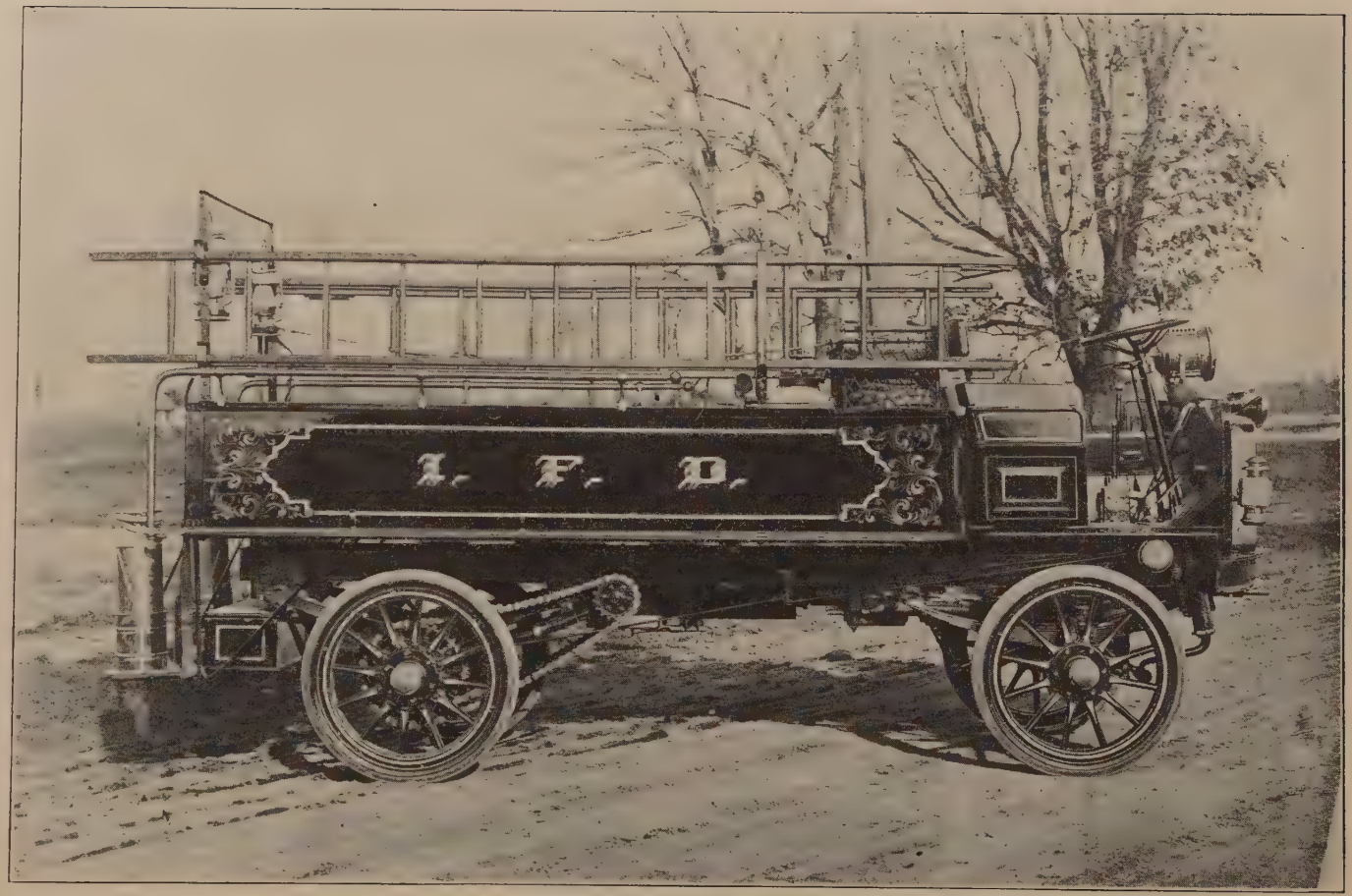


Fig. 90. Knox Fire Wagon.

with a 40-horse-power, four-cylinder, vertical motor, with 5-inch by 4¾-inch cylinders of the water-cooled type, and a special, heavy, three-speed transmission of sliding-gear pattern such as is employed on all the heavier Knox water-cooled commercial cars. The wheel base is 149 inches and the tire equipment consists of 36-inch by 4-inch single, solid rubber tires forward, and dual tires of the same dimensions on the driving wheels. The chassis weighs 5,400 pounds and its capacity of 8,000 pounds load, brings it up to approximately the total of 14,000 pounds which this most modern of fire-fighting vehicles weighs with its full equipment of high-pressure hose, tools, and uniforms. In addition to these it will be noted that it is also equipped to be used as a stand pipe for the hose; and as a brass nozzle coupled to a length of 3-inch hose with 300 pounds pressure to the square inch is an extremely difficult and dangerous thing to handle, it has proved invaluable in this rôle.

A less pretentious type of fire-fighting motor wagon, intended for suburban service and now in use in New England, is shown in Fig. 90; it consists of one of the Knox 4,000-pound truck chassis with the body equipment as shown. It employs the same 40-horse-power, water-cooled motor as the heavier car, but with a regular type of three-speed sliding-gear transmission. Its wheel base is 103 inches and its tire equipment consists of 34-inch by 4-inch single solid tires in front, and 34-inch by 5-inch solid tires on the driving wheels. An intermediate type of fire-fighting machine, in which speed is one of the chief essentials, is shown in Fig. 91. This car was built for the town of Brookline, Mass., where it has been doing effective service for some time past. Its chassis is also one of the Knox 4,000-pound type, but it is equipped with a 5½-inch by 5½-inch motor developing 48 horse-power and has an extra heavy three-speed, sliding-gear transmission. It has a wheel base of 145 inches and is fitted with the largest pneumatic tires in everyday service, viz, 40-inch by 6 inch, because the combined weight of the chassis and its load carrying capacity—which are equally divided, giving it an efficiency of 100 per cent—is 8,000 pounds.

A most completely equipped, chemical fire engine of the high-speed type employed in the fire-department service of the city of Waterbury, Conn., is shown in Fig. 92. It has a 40-horse-power chain-driven Locomobile chassis equipped with a four-speed, selec-

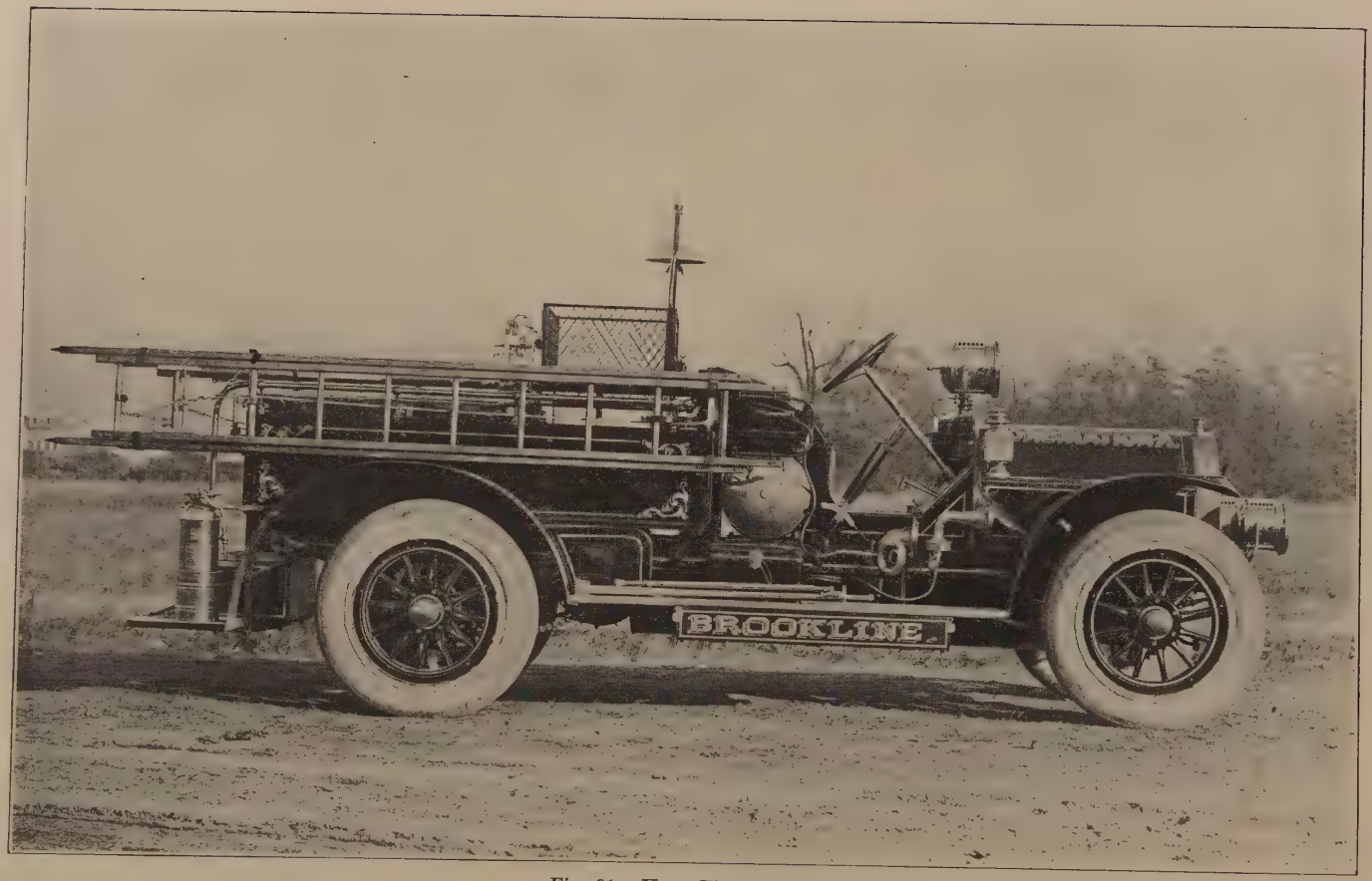


Fig. 91. Knox Fire Wagon.

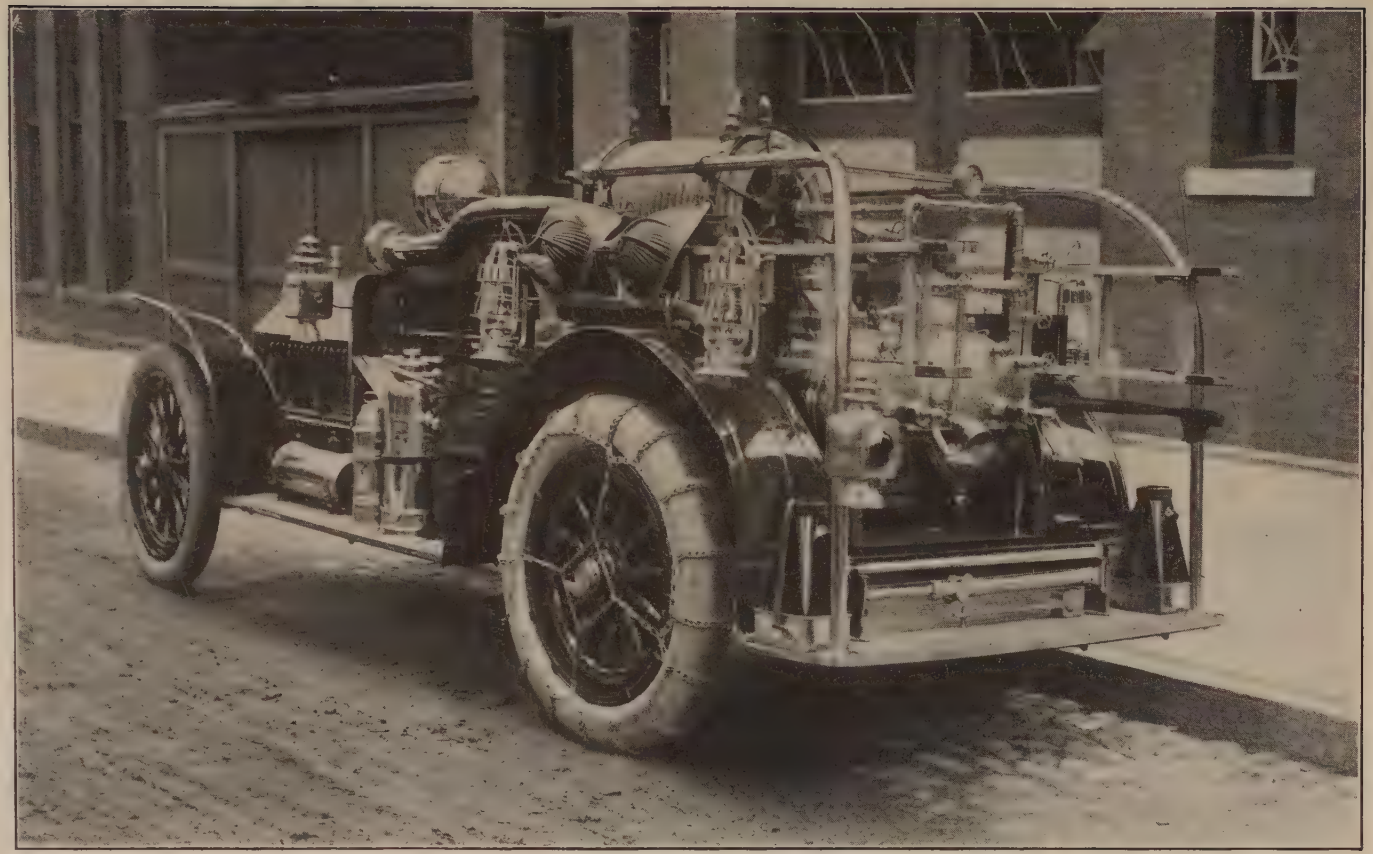


Fig. 92. Locomobile Chemical Outfit.

tively operated, sliding gearset. It carries a large chemical engine designed to be operated by hand, a reel of hose, and the other usual fittings, and has a large acetylene searchlight for use in night fire-fighting as well as driving. It is fitted with pneumatic tires, the rear tires measuring 40 inches by 6 inches.

To attempt to describe all the special types of gasoline vehicles built would involve a reference to practically every form of horse-drawn vehicle that has ever been constructed, besides many more, as the power wagon lends itself to special forms of service to much better advantage than its predecessor, as illustrated by Fig. 93, which is a Knox self-dumping contractor's wagon. This is a medium capacity truck chassis equipped with a two-cylinder, horizontal,

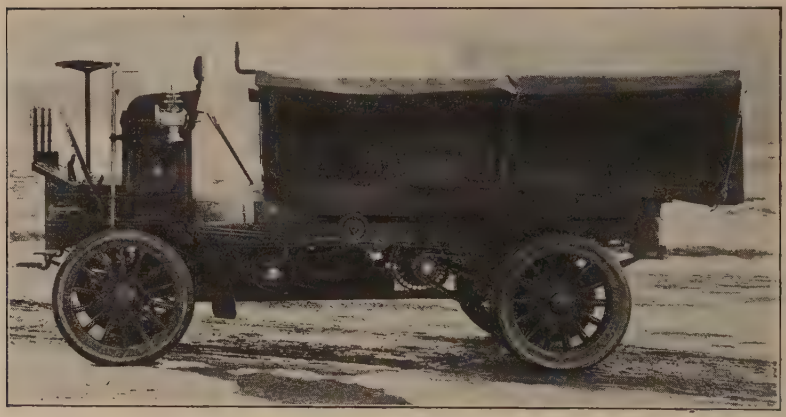


Fig. 93. Knox Self-Dumping Contractor's Wagon.

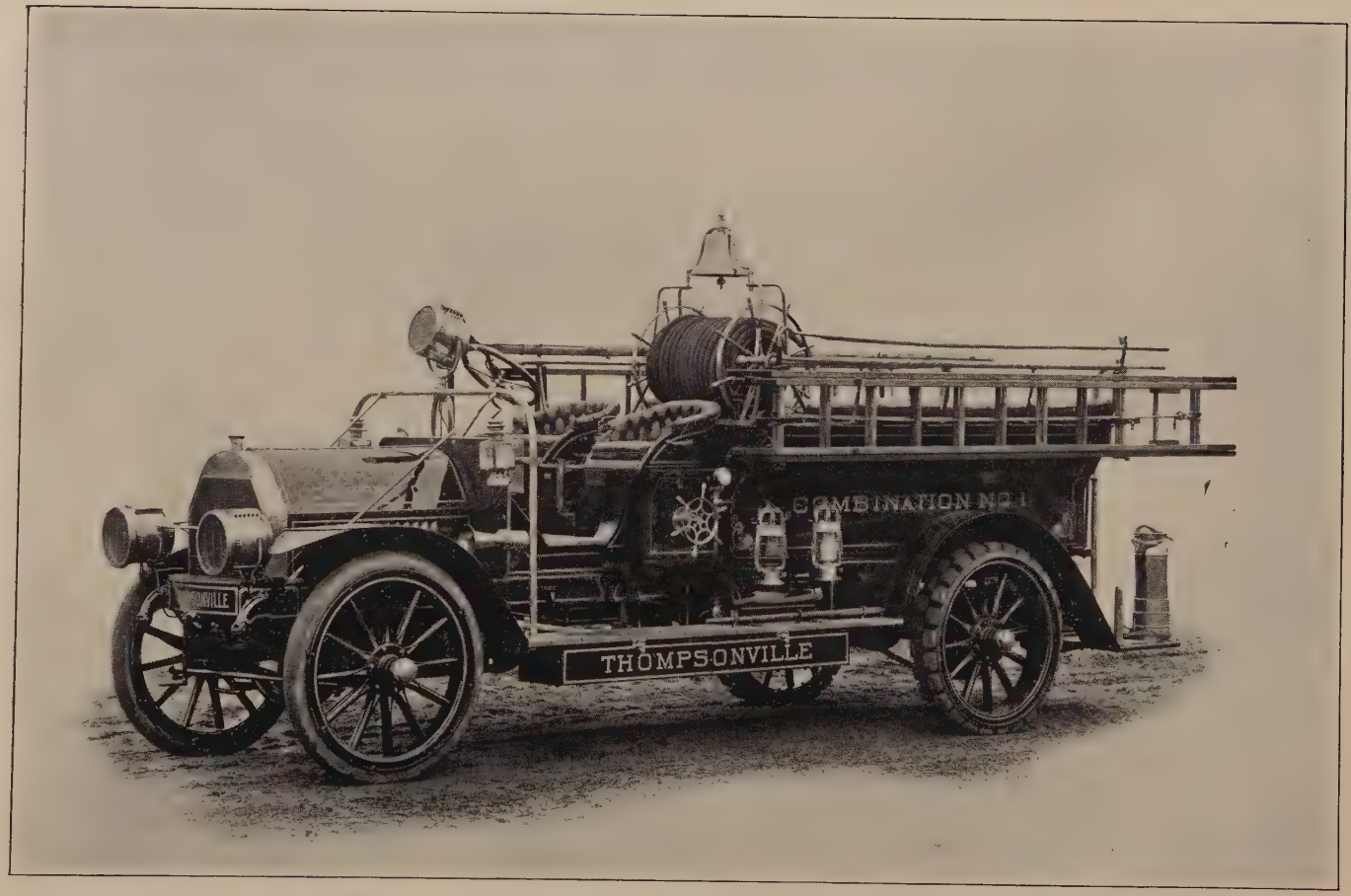
opposed, air-cooled engine driving through a two-speed planetary gearset to a countershaft by single chain. From the countershaft the usual double side-chain drive is taken to the rear wheels. Interest naturally centers in the self-dumping mechanism, which is shown in action in Fig. 94. This consists of a countershaft attached to the upper side of the frame and driven from the motor by a single short chain through sprockets giving a speed reduction of about $2\frac{1}{2}$ to one. This shaft is thrown into action by the right-hand lever illustrated. At its center it carries two small bevel pinions arranged to be slid in or out of mesh with a larger bevel gear attached to a long threaded shaft, giving a second speed reduction in about the same ratio. Two

Fig. 94. Knox Contractor's Wagon Dumping a Load.

Fig. 95. Hewitt Truck Fitted for Telephone Cable Service.

Fig. 96. Brennan Street-Railway Tower Wagon.

Fig. 97. Manhattan 16-Passenger Omnibus.



KNOX MODEL M-3 COMBINATION CHEMICAL HOSE AND FIRE CAR

Knox Automobile Company, Springfield, Massachusetts

Fig. 98. Knox Omnibus.

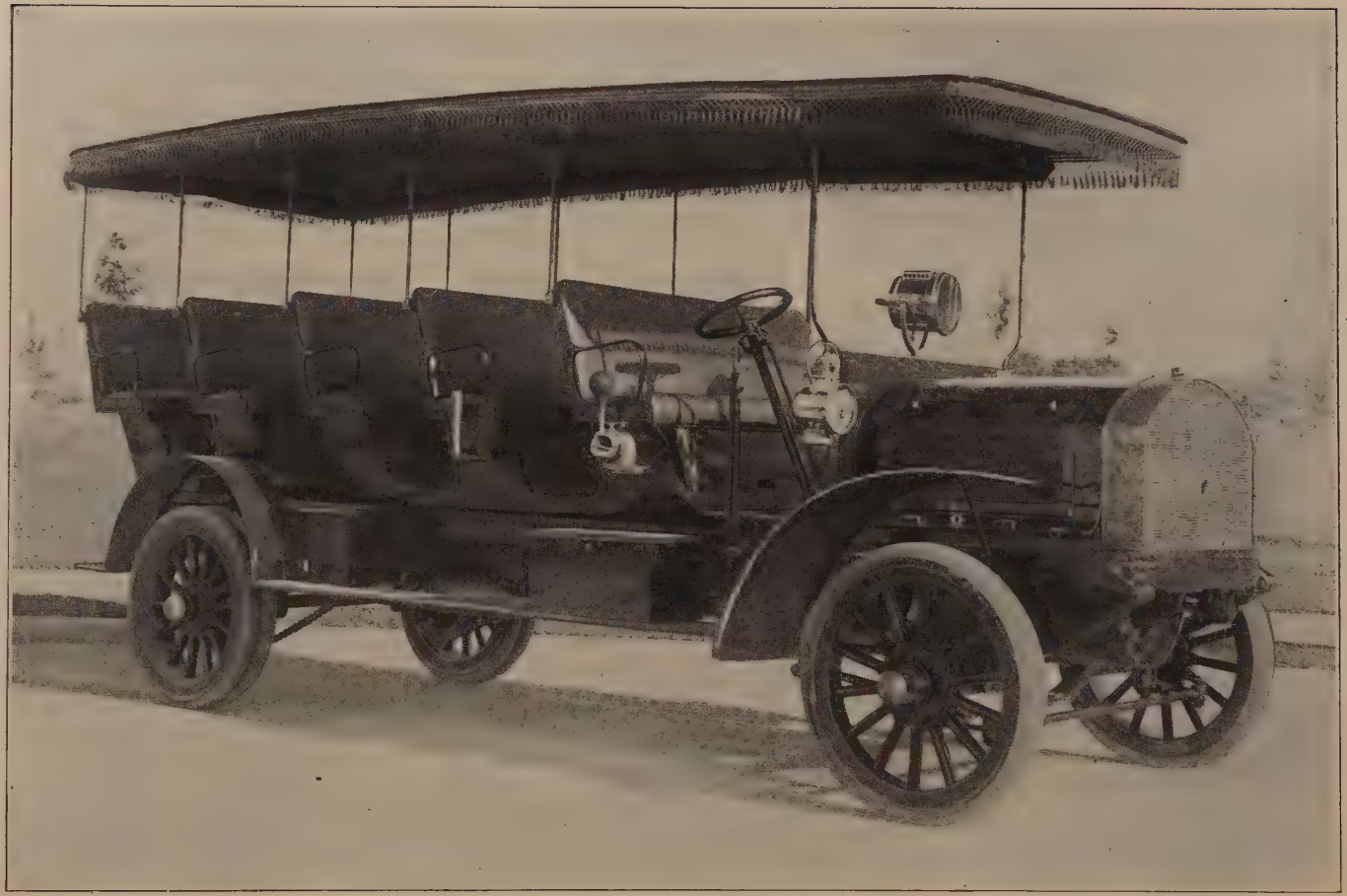


Fig. 99. Manhattan Sight-Seeing Wagon.

travelers linked to arms attached to the underside of the body engage the screw thread of the long shaft and slide on a narrow platform just beneath it. By throwing the left-hand operating lever in one direction the shaft is turned through one of the small bevel pinions so as to raise and dump the body. Engaging the opposite pinion reverses the movement and returns the body to its normal loading position, the entire operation only requiring a few minutes.

The Hewitt 3-ton truck, Fig. 95, affords another instance in which the power wagon presents a great advantage over the horse-drawn type for special service, this truck being equipped with a windlass driven by the motor and employed to haul the heavy, lead-encased telephone cables in and out of the conduits. In Fig. 96, is shown a Brennan 50-horse-power, emergency tower wagon used in the St. Louis street railway service. Speed is naturally its chief advantage as this permits it to effectively serve a territory of far greater area than would be possible with the use of a single, horse-drawn tower wagon. Fig. 97 represents a "pay-as-you-enter" type of bus built on a Manhattan 50-horse-power chassis and designed to be operated entirely by one man. It will seat 16 passengers comfortably. A lighter type of vehicle is shown in Fig. 98, this having as its foundation a Knox 40-horse-power, 4,000-powered chassis. A typical "sight-seeing" car is shown in Fig. 99, which is built on the same type of Manhattan 50-horse-power chassis as the bus, Fig. 97.

GASOLINE-ELECTRIC VEHICLES

Problems of Transmission. *Planetary Gearset.* Where the total weight to be transported as a unit is much in excess of five tons—which means five tons of useful load and anywhere from three to three and a half tons of dead weight in the shape of the vehicle—the use of a mechanical method of altering the ratio between the engine and the driving wheels presents far more than the usual difficulty. In large measure, this is due to the terrific stresses imposed on the gear teeth when starting the load from rest, and in order to provide for this adequately, the gear box as a whole must be made disproportionately large. It will be noted that the Hewitt 10-ton trucks employ a gearset, but this is of the planetary type in which the load is distributed over a number of comparatively small pinions which are always in mesh, thus obviating not only the high pressure per gear

tooth, but likewise the necessity of sliding the gears in and out of mesh. This type of gearset has the further advantage of employing simple band clutches for the low and reverse speeds, which, like the remainder of its mechanism, are practically proof against abuse, even in the hands of the most unskilled driver. But it has the great disadvantage of not providing more than two speeds forward as a three-speed planetary gear involves an almost prohibitive amount of complication in design, because of the number of small pinions necessary. Its efficiency is, likewise, not as high as the sliding gear type, so that its simplicity and "fool-proofness" are its chief recommendations. With the exception of the Hewitt heavy trucks, it is not employed on anything bigger than a delivery wagon, or light truck, of about 1½-ton capacity.

Low First Speed. The fact that this planetary type of gearset is not capable of providing more than two speeds forward, means that the first speed has to be low enough to move the vehicle under any conditions that it is designed to meet. On a 10-ton truck, the first speed would not move the vehicle much in excess of two miles per hour, and as conditions under which the vehicle would be forced to drive on first speed would often occur, the motor efficiency would fall off in consequence. One of the chief and inherent short-comings of the internal combustion motor, as already pointed out, is its low torque, or pulling power, at speeds much below or above its normal r. p. m. rate. To work efficiently, it must accordingly be run as close to its normal speed as possible at all times.

Electric Transmission. It thus becomes evident that it is an important matter to provide as many speeds as possible or changes of gear ratio, between the motor and the driving wheels, in order that the motor may always be run at a practically uniform speed. For this reason, the sliding type of gearset with three or four changes of gear ratio is an improvement over a gearset providing but two forward steps; but even the former falls far short of providing the wide range of running speeds desirable for driving a heavy vehicle.

Up to the present, nothing but an electrical type of transmission has been found to afford the universal flexibility so necessary for starting and running a heavy vehicle and its load by means of an internal combustion motor. The initial expenditure involved in the building of a vehicle thus equipped is naturally far greater than where a purely

mechanical form of transmission is employed, but it offers a number of advantages, not the least of which is its silence in operation as compared with a car with a sliding gearset.

Types. The electric transmission is a very desirable feature for passenger service on city streets and a number of buses of this type, Fig. 100, are in use on the Fifth Avenue stage line, New York. The equipment employed in its essential features is very similar to the tractor of the Sampson gas-electric road train described, Page 142. The usual four-cylinder, vertical, four-cycle gasoline motor is employed as the prime mover, direct coupled to a direct-current multipolar generator. This generator set runs at a uniform speed regardless of the load, or whether the vehicle is moving or standing still, although the motor may be controlled by the driver in exactly the same manner as when the transmission is mechanical. It accordingly uses fuel only in proportion to the demands made upon it, and as the motor speed is practically uniform at all times, the efficiency is high and the fuel consumption correspondingly lower than where the motor itself must provide for a large proportion of the speed changing. Where extra power is needed for an emergency the speed of the generator may be increased by running the motor faster, thus giving the set considerable overload capacity.

From the generator, the current is led through a control somewhat similar to that usually employed on street railway cars, so that in starting and stopping the vehicle, the driver does not have to shift gears or pay any attention to the motor, but depends entirely on the electric controller. The current is utilized to drive two direct-current, series-type motors, similar in design to those ordinarily employed on electric automobiles, but as neither the power nor the voltage is limited by the use of a battery, the current is employed at a higher potential, permitting the use of a very light and compact motor for the power developed. As will be plain from the illustration, these motors drive by gears to independent countershafts bolted directly to the motor casing. The countershaft carries a sprocket at its outer end from which a chain is taken to a larger sprocket on the driving wheel, giving a second reduction between the motor and the road wheels. As each motor drives its wheel independently, a differential is eliminated, and in case of accident to one of the motors the vehicle can be driven back to the station with the other.

Fig. 100. General Electric Company Gas-Electric Bus.

The chassis of another form of gasoline-electric commercial vehicle is shown in Fig. 101. In so far as the power plant is concerned, this consists of the usual four-cylinder, vertical, high-speed, four-cycle gasoline motor, direct-connected to a multipolar, direct-current generator, the entire unit being mounted directly over the front axle and under the footboards as shown in the illustration. The controller of the street-railway type will be seen at the other side of the steering wheel, where its operating handle is most conveniently placed for the driver. The volt-ammeter will also be noted, mounted on the sloping part of the footboards and in plain view of the driver

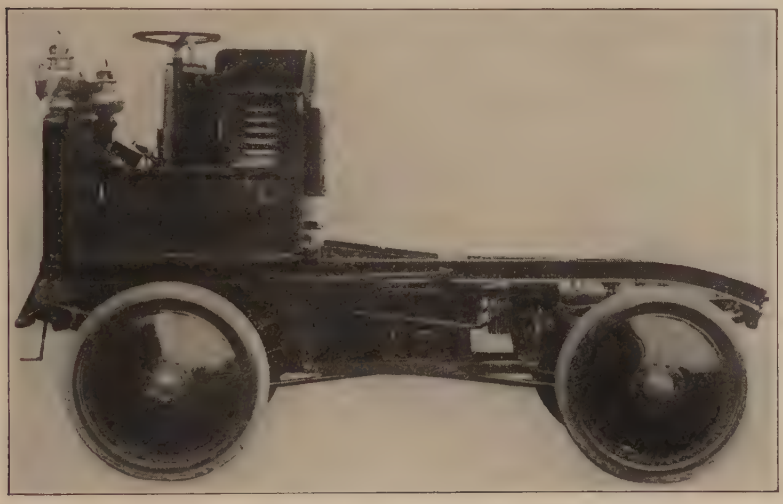


Fig. 101. Chassis of a Gasoline-Electric Truck.

from his seat, while the rheostat will be seen attached to the chassis frame just forward of the rear wheels. The vehicle is known as the *couple-gear* truck owing to the fact that all four wheels are utilized for steering. The method of connecting the steering gear employed for this purpose is plainly visible in the view of a complete truck, Fig. 102. The drive takes the form of an independent electric motor incorporated directly in each wheel, all four being used for driving as well as steering, as described, Page 36. As every one of the wheels is employed to drive the vehicle, all are equipped with dual solid rubber tires, it being the usual practice to employ the latter only on the rear wheels of the ordinary form of truck.

As already pointed out, the gasoline-electric vehicles, or the gasoline truck with electric transmission, afford many advantages in the way of simplicity, combined with a practically universal range of speed changes, from starting to maximum, owing to the various relations that may be brought about between the generator and the motors with the aid of the controller. As a matter of fact, several speeds forward and two or three reverse are provided, which is naturally a far greater number than would be possible with any mechanical form of speed change. A further element of economy is contained in the fact that the speed of travel of the vehicle has no bearing on

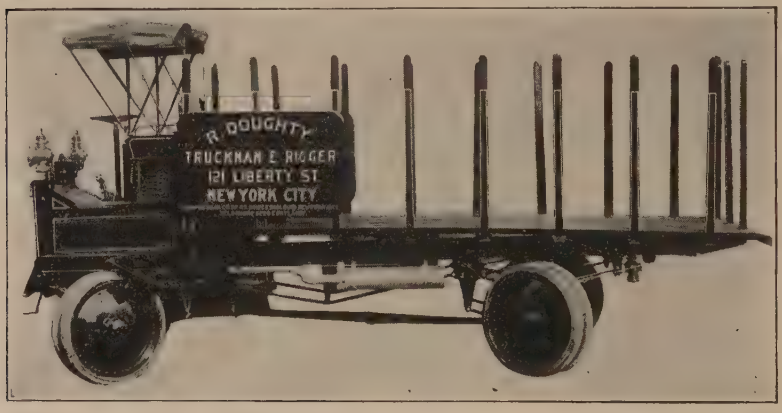


Fig. 102. Couple-Gear Truck Showing Steering Device.

that of the gasoline motor, the latter being operated at its most efficient r. p. m. rate.

These advantages have been found to offset the increased initial cost of building commercial vehicles of the gasoline-electric type, to judge from the number now in service. These vehicles have the further advantage of a low maintenance cost due to the great degree of simplicity and reliability which is characteristic of the electrical portion of the equipment. From the foregoing, it would appear as if the gasoline-electric type of vehicle was destined to fill a place of rapidly increasing importance in the field of commercial vehicles. The use of gasoline-electric street cars, treated in another article, shows the versatility of this method of propulsion.

STEAM VEHICLES

It will scarcely be necessary to mention the fact that the commercial steam vehicle has not been developed to any great extent in this country and is far from being a factor of importance in this field, as this is self-evident from the types of trucks in use. It might be inferred from this that steam had not been found particularly available for commercial use, but quite the contrary is the case, as in England it has doubtless reached about as high a degree of development as this form of power is capable on a road vehicle, while about as much attention has been devoted to it in France as here. As a matter of fact, the steam commercial vehicle has been developed in Great Britain at the expense of the gasoline type up to within a very few years ago. These steam cars, which are employed both in the form of "lorries" (trucks) and tractors, are ponderous and slow-moving affairs which, in some instances, are really not very far removed from the road roller and in others are about the same as the familiar farm tractor used here. But with all the inconvenience of burning coal and maintaining a boiler, they are clung to with a tenacity that is characteristic of British conservatism. They have the saving grace of being cheap and as they have served for some time past, they will doubtless hold on for some time to come.

Types. Specialized types of steam trucks have also been developed, in which the power-plant is in a very compact and efficient form, though none of the disadvantages of coal burning or very slow rate of travel have been eliminated. Two trucks of this type were tried out by one of the large express companies in this country several years ago, but it was evident from the first that they were not destined to fulfill American ideas of what the commercial motor vehicle should be, and a comparatively few months of service sufficed to demonstrate this.

Michigan. At the present writing there is practically only one specially-designed, steam commercial vehicle of American make on the market—at least, so far as the writer knows—excluding traction engines, of course. This is the Michigan steam truck, which is built in sizes ranging from 1-ton to 10-ton capacity, thus including delivery wagons as well as trucks from the smallest to the largest types now built in other powers. They are equipped with a quad-

ruple compound-condensing engine, *i. e.*, there are two sets of four cylinders each, placed at 90 degrees to one another, the connecting rods of the opposite cylinders acting on a common crank pin. This engine is rated at 20 horse-power at 900 r. p. m., with an overload capacity of 100 per cent; it is non-centering and has no flywheel. Each group, or nest of cylinders, consists of high-, intermediate-, and low-pressure cylinders, all controlled by piston ring valves. All four pistons of each nest operate through two rods on one crosshead, and the crosshead operates through a single connecting rod

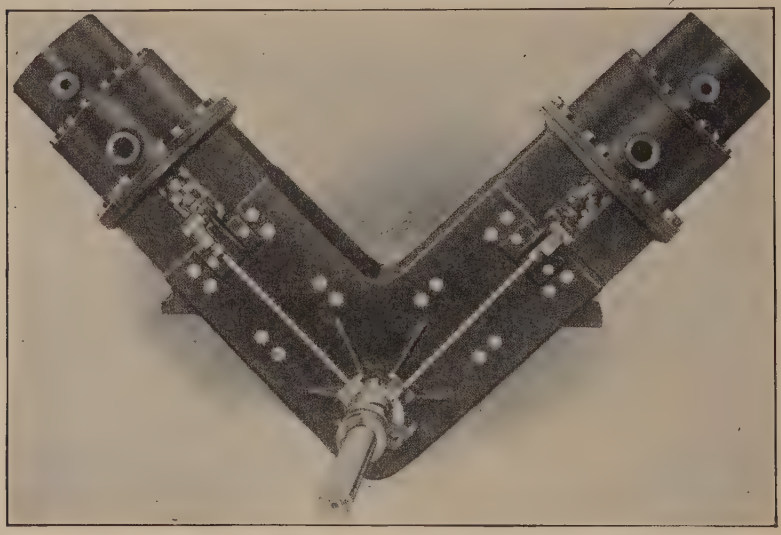


Fig. 103. Michigan Steam Motor Showing Valve Mechanism.

on the crank on the shaft, the latter being provided with a balance weight. As already mentioned, the valves are of the hollow piston type, the valve-operating gear consisting of a spiral eccentric gear revolving on the shaft. This control permits of instant and easy reversing of the engine and is claimed to be very simple. The cylinders of the engine are of 2-, $2\frac{3}{4}$-, $3\frac{1}{2}$-, and $5\frac{1}{2}$-inch bore respectively, with a uniform piston travel of $3\frac{1}{2}$ inches and a valve travel of $\frac{5}{8}$-inch. The steam is cut off at $\frac{7}{8}$-inch of the stroke, making the engine very economical. Its compactness may be judged from the fact it measures but 34 by 22 by 15 inches over all. It is connected with a 28-inch by 40-inch oiler. Steam is carried at 350 pounds to the square inch and is superheated. The general appearance of the engine is

illustrated in Fig. 103. The high and first intermediate cylinders are controlled by one valve, and the second intermediate and the low by a second valve, the cylinders and valves being placed tandem. The valve mechanism on the back of the engine, as shown, runs direct from a reversing eccentric, operating on the shaft as a sleeve and with a spiral cut in it.

Generally speaking, the remaining features of the construction of the Michigan truck do not differ materially from those of the ordinary gasoline type. The motor is placed forward under a short

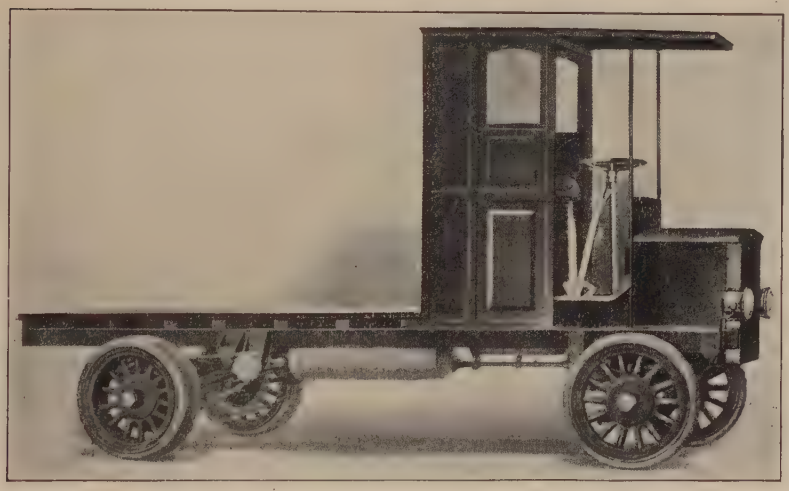


Fig. 104. Michigan Steam, 3-Ton Truck Chassis.

bonnet, the condenser being placed in the usual position of the radiator, while the steam generator is under the driver's seat. Drive is direct from the motor through a long, horizontal propeller shaft to a bevel differential on a countershaft from which the power is transmitted by sprockets and chains to the rear wheels. The usual wheel steering is employed, the throttle being mounted on the steering pillar, while the hand levers shown are for reversing the engine and putting on the brakes. A 3-ton chassis is shown in Fig. 104.

White. Apart from this specially designed steam truck, the only steam commercial vehicles on the American market are the White cars. Here the same chassis as is employed for the pleasure car is also used for commercial purposes and quite a number of

vehicles have been supplied for ambulance, patrol, and other municipal service, as well as for the use of the Federal government. As is evident from Fig. 105, they do not differ in appearance from the usual gasoline type. The power plant of the White steam car consists essentially of a steam generator, a burner, and an engine, together with the necessary devices for supplying water to the generator and fuel to the burner, in proper amounts. The White steam generator does not resemble in any respect the ordinary steam boiler, and it has doubtless been due to its many points of superiority over the usual type of boiler for automobile service that these cars have met with such wide-spread success.

The White generator, in the first place, has the water at the top and the steam at the bottom, while the relative quantities of the two that happen to be present is of no moment, the generator containing but very little of either at a given time. In fact, the steam is generated instantaneously, and only as fast as it is needed, due to the continuous tubular construction of the generator, which is practically one coil, having but twelve joints, as compared with the many hundred in the usual fire- or water-tube boiler. The White generator consists of nine coils of steel tubing of $\frac{1}{2}$-inch internal diameter, one above the other and connected in series, so that if straightened out, the entire construction would represent but a single piece of tubing. The water or steam, in order to pass from an upper coil to the one next below, must be forced up to a level above the top coil and then down again, preventing the water from descending by gravity and making the circulation dependent entirely upon the pumps. In operation, water is pumped into the upper coil and steam issues from the lowest coil. The precise point in its travel at which the water "flashes" into steam has never been precisely determined. From its action, this type of boiler is known as a *flash generator*, the small quantity of water and steam it contains at any moment being evident from the fact that its volumetric capacity is less than $\frac{1}{3}$ of a cubic foot. But the process of making steam is so rapid that it is always available in the quantity the running conditions of the car may call for, this being governed by an automatic thermostat.

Beneath the generator is located the burner, to which the fuel, consisting of either gasoline or kerosene, is fed under moderate pressure, maintained by an air pump attached to and driven from the

Fig. 105. White Steam Ambulance.

engine. The fuel first passes through a vaporizer and then, in the form of gas, enters the burner, where it mixes freely with air and

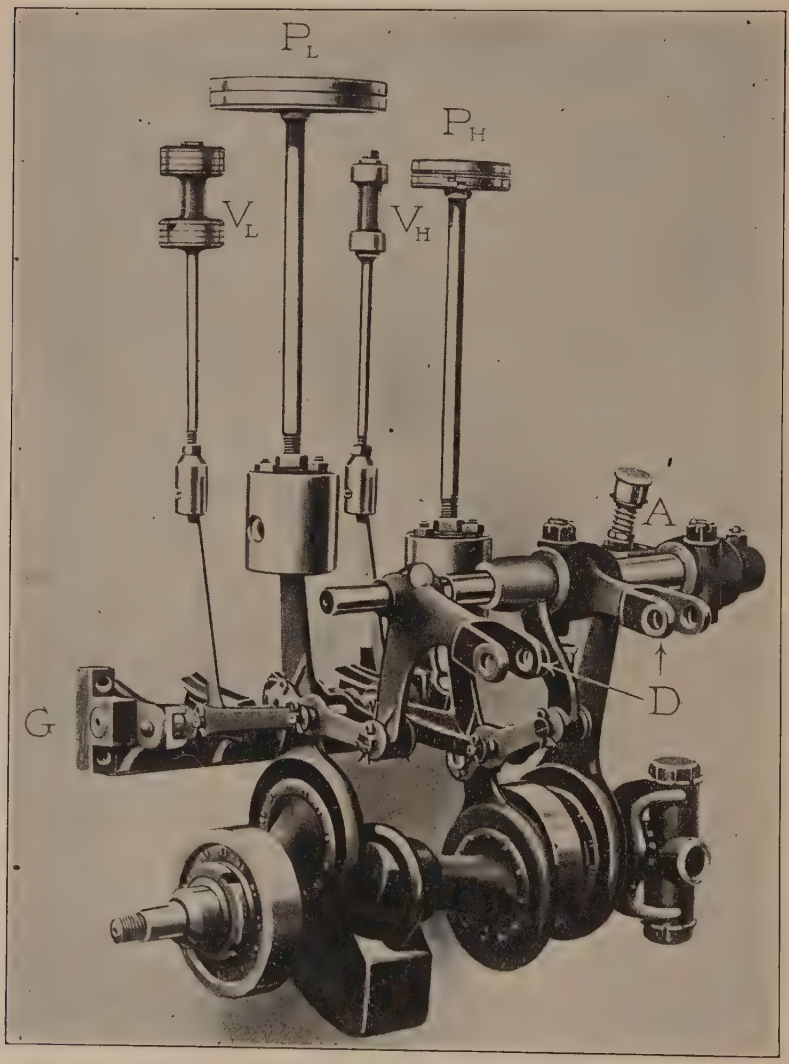


Fig. 106. White Steam Engine Showing Working Parts.

burns with a blue flame, as in the Bunsen burner. The products of combustion pass upward through the coiled tubing of the generator

and are then conducted downward through an annular flue surrounding the generator and are led to the rear of the car where their escape is not noticeable. To start the burner, a pilot light is employed, the small flame of which is kept burning constantly while the car is in use. It serves the double purpose of keeping the vaporizer at the required temperature, and of lighting the burner whenever

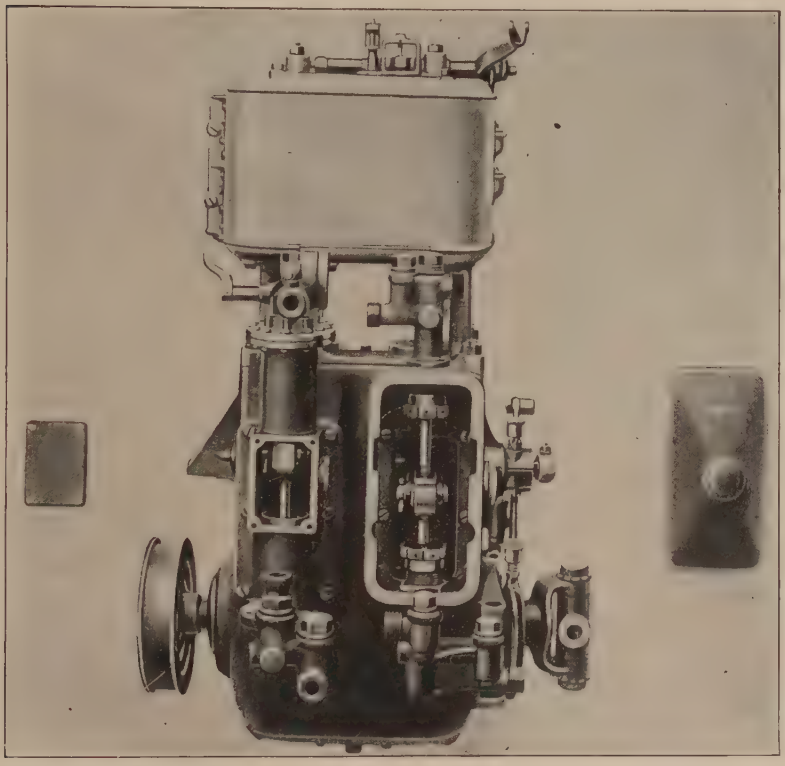


Fig. 107. White Steam Engine—Left Side—with Pump Covers Removed.

fuel is supplied to the latter. When kerosene is employed as fuel, it is necessary to use gasoline for the pilot light, but the quantity required is negligible. The vaporizer is a steel forging with a number of passages bored through it, and by its heat converts the fuel from a liquid to a gas.

The engine is a two-cylinder, vertical, compound, condensing type designed to work at about 600 pounds pressure to the square

inch. Its working parts, consisting of the crank shaft supported on large annular ball-bearings, pistons, connecting rods, crossheads, valve mechanism, and pump levers, are shown complete in Fig. 106. The valves are driven directly from the connecting rods by what is known as the *Joy type* of valve gear, the valves themselves being of the piston type. Steam is admitted through the center of the valve and exhausts at its ends; as the pressure is the same on all sides, a negligible amount of power is required to operate the valve. The crank case is made in one piece, access to the moving parts of the engine being had by large handholes, normally covered with light plates. The side plates are shown in Fig. 107, there being a third large plate on the bottom of the crank case. The engine is supported on two cross members riveted to the main frame and is so hung that the driving shaft is perfectly horizontal. As there is neither clutch nor transmission gear, the drive is direct and positive from the engine through the long driving shaft to the rear axle.

OPERATION PROBLEMS

COST

While the achievement of a degree of reliability that would permit it to compete with other forms of transportation was the first determining factor in the history of the development of the commercial vehicle, it is needless to add that the influence of greatest importance bearing upon its general adoption is cost of operation. One of the very first questions put by the intending purchaser is—"What is such a vehicle going to cost to maintain in service?"—and a large amount of engineering talent is now employed in the commercial field in the attempt to formulate an answer to this question in each individual case in which it is asked. In fact, the analysis of merchandise transportation requirements and the cost of the service as compared with old methods is rapidly developing into an engineering study of no mean proportions.

It will be evident that under the circumstances, definite figures are wanted by the purchaser, and they naturally can only be based on actual experience. The merchant who contemplates making a substantial investment in commercial vehicles wants to see something more than a mere calculation of what their services will cost—not

for a month or two months, but, as closely as can be judged, the amount they will cost to run and maintain in repair during the first year and each succeeding year of the useful life of the vehicle.

There are naturally many factors to be taken into consideration in any complete cost-accounting system that is worthy of the name, whether this be for a single delivery wagon, or truck, or a whole delivery system, such as is employed by the large retail drygoods establishments. Lack of consideration of these numerous factors has led many commercial vehicle manufacturers into stating half-truths regarding the economic performances of their vehicles in the earlier days, though it is not certain by any means that the practice has entirely disappeared even now. The revelation of the whole truth naturally proved a disappointment to the pioneer motor-vehicle users, however, and the result was a feeling of distrust. It could not have been worse had the manufacturer actually made misstatements, for the user regarded them as such in the light of his experience. To cite instances of what is meant by these half-truthful statements, there may be mentioned the cases of cost summaries which some makers print in their catalogues. Sometimes these extend over a period of three months and in others, six months, and the service records thus established are expected to be regarded as a criterion of what the vehicle is capable of year in and year out. In some cases, nothing for tire replacement is included, owing to the short time the vehicle has been in use, not to mention such other items as depreciation, interest, insurance, and other overhead charges. Seldom, indeed, is the useful ton mileage of the car over the period in question given, and quite a number of manufacturers, when approached for information on this vitally important subject, are not loth to confess that they are unable to give it and that they have never attempted to keep a record of the kind.

Some of the factors of importance are speed, reliability, wide radius of travel, and even stylishness—which is considered an asset of the motor delivery wagon—but, after all, cost must be practically the sole governing factor by which the commercial motor vehicle is to be judged. At the outset, it was really the uncertainty—that lack of reliability which made the successful completion of a day's trip an entirely unknown factor—that first militated against the commercial vehicle; but since improvement in design, materials, and construction has

eliminated that, the item of cost of operation is really paramount. It manifestly lies more within the province of an article on cost accounting for commercial vehicle service, than of one which deals almost entirely with the engineering side of the subject. Consequently, the aim has been more to demonstrate what the commercial vehicle is capable of—particularly as compared with former methods by horse haulage, figures on the cost of operation being cited more to show the superiority of the power wagon from an economic standpoint as well—rather than to attempt to set forth exactly what has been or can be done in operating one or more vehicles.

Gasoline. Leaving aside the matters of interest, depreciation, insurance, and repairs, it will be apparent that in the commercial vehicle, fuel, lubricant, and tires are of far more importance than in a pleasure car. One of the small 500-pound delivery wagons will usually travel from 25 miles to 30 miles on a gallon of gasoline, averaging better than 20 miles; a 10-ton truck will average less than three miles to the gallon of fuel. Between these two extremes, there is a wide range, a 1,500-pound delivery wagon running from 12 miles to 20 miles to the gallon, with an average of about 15 miles, while a 3,000-pound machine (the figures refer to load capacity and not to chassis weight) will not do better than from 8 miles to 15 miles per gallon, with an average around 10 miles. A 3-ton truck will range from 4 miles to 10 miles, the difference in every case naturally depending not only upon whether the vehicle is loaded or not, but also upon differences in the road surface and grades of its routes. The 5-ton wagon can travel from 3 miles to 5 miles on a gallon of fuel, its average being about 4½ miles as compared with 6 miles for the 3-ton size. A 14-ton road train may require as much as two gallons of fuel for every mile covered, but will doubtless not be found to greatly exceed a gallon to the mile, except where the going is particularly bad.

Lubricating Oil. The consumption of lubricating oil ranges between even wider limits than that of fuel, as will be apparent from the fact that in a commercial vehicle trial in which a large number of representative foreign vehicles competed, the ratio between the most economical and the most wasteful was fully five to one. In other words, some cars consumed five times as much lubricating oil per mile as others in the same class. But then certain of the European cars have proved to be highly economical in the use of lubricant and

it is doubtful if there would be as wide a range between the same number of American commercial cars, as few of them have approached the degree of economy achieved in this respect by the French designer. Experience has shown that the minimum consumption of oil, which should be of the very best quality for the purpose, is about one gallon for every 14 to 15 gallons of fuel used by the vehicle, while the maximum is, approximately, one gallon for every six gallons of gasoline. Where much hill-climbing is the rule more oil would necessarily be used, owing to the motor running for longer periods on the lower gears and under correspondingly heavier loads. These figures are based upon ordinarily competent management of the machine, and while an expert driver, thoroughly conversant with his machine, and supplemented by painstaking garage attendance, might do somewhat better, incompetence in either of these departments can swell these figures so tremendously that there is no means of estimating to what proportions they may attain.

Tires. Next to fuel and oil come tires, and in figuring on this subject an engineer who has had five years' experience in the commercial field in a consulting capacity, gives the following: For a 500-pound wagon, $\frac{3}{4}$-cent per mile minimum, $2\frac{1}{2}$ cents maximum, average $1\frac{1}{2}$ cents; 1,500-pound class, or regular delivery wagon type, 1, minimum, $3\frac{1}{2}$, maximum, and $2\frac{1}{2}$ cents average per mile; 3,000-pound class, $1\frac{1}{2}$, 5, and $3\frac{1}{2}$ cents per mile; 3-ton class, 2, 7, and $4\frac{3}{4}$ cents per mile; 5-ton class, 3, 10, and 6 cents per mile. Against these figures, may be placed those which the builders of the Manhattan cars give as the result of five years' experience in the running of a large number of their own vehicles. Manhattan 2-ton truck, 2 cents per mile, the figure in each case being the average; 3-ton truck, $2\frac{1}{2}$ cents per mile; 4-ton truck, 3 cents per mile; and the 5-ton truck, 4 cents per mile, this last falling between the minimum and the average for this class in the foregoing figures. Unfortunately no data is available at the moment on tire costs on the electric vehicles, though it may be stated definitely that owing to the lower average speeds and the greater ease with which the load is started by the electric motor, this type of vehicle shows much greater economy in tires than the gasoline car, though exactly how much is a question that could only be answered by a direct comparison of the figures.

Total Cost of Operation. The cost of operating various sizes of trucks is given in a different light by the makers of the Hewitt cars. The figures are based on five years' constant operation, the vehicle averaging 300 days in service—a task which should not be difficult of accomplishment. On this basis, and figuring an average run of 50 miles per day, the tire figures for a Hewitt 2-ton truck are given as $1.34 per working day, or $.0268 per mile, which will be found to practically agree with the averages already cited. On the same basis, the tire cost of the 3-ton truck, averaging 45 miles per day, 300 days in the year, for five years, is $.037, or slightly more than 3½ cents per mile, as compared with the average of 4¾ cents given in the first instance. This and other similar discrepancies between the two may well be accounted for by the long period of operation upon which the Hewitt averages are based, this naturally being more conducive to a favorable showing. Under similar conditions and averaging 40 miles a day, tire costs for a 5-ton truck are $.0583 per mile—practically the same as the 6-cent average for the same type in the first table. The cost of tire mileage naturally reaches its maximum on the 10-ton size, the Hewitt figures for their vehicles of this class being $.111 per mile, or between 11 and 12 cents.

From a basis of a five-year period of operation, it will be of interest to compare daily total costs of operation in a few instances. The following figures are given by the makers of the Manhattan trucks and are based on an average run of 50 miles per day. For a Manhattan 2-ton truck, the total daily operating cost—exclusive of depreciation, insurance, and similar items as already mentioned—is $5.88; composed of $1.50 for gasoline, five miles to the gallon at 15 cents a gallon; cylinder oil, one gallon, 38 cents; repairs and renewals 50 cents; tire changes, 2 cents per mile, or $1; and the driver's wages, $2.50. Similarly figured, the 3-ton truck will run 50 miles a day for $6.78, the 4-ton, $7.50, and the 5-ton, $8.00. According to the makers of the Manhattan trucks, these figures are based upon several years' experience in the handling of a large number of machines, and to show how closely they agree with what other makers have found under similar circumstances, they may well be compared with those of the Hewitt machines in the same sizes.

Taking the Hewitt figures on a daily basis, that of the 2-ton truck, based on exactly the same items, is $5.72 as compared with

$5.88, though labor in the case of the Hewitt is included at $3 per day, gasoline (15 cents per gallon) at only 90 cents, and lubricating oil (30 cents per gallon) at only 15 cents, while tire charges are more, or $1.34. In fact, there is hardly an item in which there is not a noticeable discrepancy, yet the totals are so close together as to be almost identical. In the 3-ton size, the charges are $6.22 per day of 45 miles travel, compared with $6.78 per day of 50 miles travel for the Manhattan, so that the totals are really equally close in this case as well. For the 5-ton, the cost is $8.30 for the Hewitt's run of 40 miles as compared with $8.00 for the Manhattan on the basis of 50 miles per day. That figures such as the above may be misleading to an intending purchaser will be evident from the further detailed costs cited by the makers of the Hewitt cars. These include every possible factor of expense, including depreciation, interest on the investment at 5 per cent, labor, tires, yearly overhauling, current repairs, gasoline, oil, total cost of insurance, and cost of storage and garage attendance.

They go to show that instead of involving a daily total expense of but $5.72, this should be $9.60 in the case of the 2-ton truck; $10.38 instead of $6.22 for the 3-ton size; and $12.67, instead of $8.30 for the 5-ton truck.

Mention has been made under *Gasoline-Driven Trucks* of the fact that the 10-ton size is about the maximum which it has been found commercially practicable to build as a single unit, the motor road train being employed where it is desirable to transport larger loads than this at one time. The Hewitt 10-ton truck is the only representative of this class and some figures of its service performance will be of interest. They refer to the truck, Fig. 75, and are based on what it did during the last four months of 1909. The daily run varied from 34 miles to 37 miles, with an average of 35.4. During 13 days in October, one of these huge trucks delivered 1092.39 tons of coal, the round trip varying from 5.5 miles to 15 miles. The average tonnage per day was 84.03, or 8.3 loads per day, which were made on an average gasoline consumption of a little less than 12 gallons, or 2.97 miles per gallon. The maximum cost of operation per day was $16, including all charges, which gave an average cost of $.19 per ton of coal for delivery. The weight of the empty car is 13,000 pounds, while the average weight of the load was 20,250

pounds, giving a total of 33,250 pounds and making the average rolling load, full and empty, 23,125 pounds. This gives a ton-mileage of 34.43 per gallon of gasoline, which is an excellent showing.

While no serious attempt has been made to analyze the cost of operation of the commercial vehicle on a general scale, the figures cited are all given as the result of several years' experience on the part of those who are in a position to be cited as authorities in the matter, so that the totals may be taken as a criterion. In other words, the student who finds himself called upon to analyze the cost of a motor delivery system and put his finger on the item that is making havoc with calculations made in advance, may take it for granted that the facts are fully representative of what may be accomplished by well-built cars of the heavier types in the hands of *competent* men—a term which is not intended to include either a factory expert or a novice.

FUELS

Gasoline. So long as gasoline represents not alone the most efficient fuel for use in motors of the present type, but likewise the most convenient, it will doubtless continue to be generally employed for pleasure-car use, regardless of its increasing cost. This effectively answers the question as to why kerosene is not used for pleasure-car propulsion. It is quite true that kerosene is cheaper and its value as a fuel for the internal-combustion motor is slightly greater than that of gasoline, but to realize its greater value it requires a motor designed to give a heavier initial compression. Furthermore, it is not as convenient as gasoline, for preheating is required to start the motor from cold, because of the higher specific gravity of *kerosene, which makes it less volatile, causing it to leave unsightly grease stains on anything with which it comes in contact.

Similar conditions naturally do not obtain in the commercial field, where the demand is for the most efficient and economical fuel. In view of the enormous increase in the demand for gasoline, coupled with the fact that the crude petroleum supply shows a constantly decreasing proportion of the more volatile products—the new wells of the Southwest are said to yield an oil producing not more than five per cent of gasoline in the process of fractional distilla-

*Note—Gasoline ranges from .62 to .67 sp.g. or 95 to 80 degrees Baumé, while kerosene is approximately .80 to .82 sp.g. or 46 degrees Baumé.

tion—it is evident that it is only a question of a comparatively few years when gasoline will have reached a point where its use for commercial service will not be economically practical. By improving the methods of utilizing the fuel in the internal-combustion motor it will become possible to use petroleum of lower and lower grades, the Diesel motor now running directly on crude petroleum with an efficiency far in advance of the most economical steam plants as well as of most other forms of internal-combustion engine. But to accomplish this an extremely high compression is necessary—500 pounds to the square inch—and the weight involved in a construction required to stand such a pressure naturally makes the use of this type of motor out of the question on a vehicle. Instead of being employed in a carbureter in the manner usually followed on the automobile, air alone is compressed to this high pressure and the fuel is then injected in the form of a spray directly into the combustion chamber, at or slightly before the beginning of the power stroke. The heat generated by the extremely high compression automatically ignites the charge. While it does not appear probable that the employment of pressures sufficiently high to accomplish this will become possible on the commercial vehicle in the near future, the method of injecting the fuel directly into the cylinder, instead of first carbureting air as is now done, will doubtless have an important bearing on the solution of the fuel problem.

Alcohol. Though volumes have been written during the past few years, on the subject of alcohol as the coming fuel, it is the prevailing impression that despite favorable legislation which has made the employment of tax-free denatured alcohol possible, production has not reached a point where its employment on a general scale is commercially practical and that few attempts have been made to use it in actual service. The fact that gasoline can still be produced at a price which makes it impossible for alcohol to compete with it, has tended to delay the distillation of the latter on a large scale for fuel purposes, besides retarding the manufacture of engines specially adapted to burn it. When employed in an engine designed to run on gasoline, alcohol is neither commercially nor practically efficient, owing to its greater cost and the greater consumption per horse-power, as well as the lower output of the same size motor, due to the lower compression. But that it can be made so under proper conditions

of operation is shown by the Hewitt trucks, described on Page 115.

The manufacturers of these heavy trucks offer their 5-ton and 10-ton types, equipped with a motor designed to run on alcohol without any extra charge to the purchaser. In these motors, the same quantity of alcohol develops a greater percentage of power than gasoline does in a motor designed for the latter fuel. While the burning of an alcohol-and-air mixture is attended by the generation of temperatures almost as high as the gasoline-air mixture creates, nevertheless, because of a peculiar phenomenon which has not been satisfactorily explained, a greater proportion of the heat is absorbed and there is considerably less tendency on the part of the motor to overheat when running under a heavy load. In other words, less of the heat that cannot be taken advantage of in the generation of power has to be absorbed by the water jackets and dissipated by the radiator. This is thought to be due to the fact that alcohol is never anhydrous. It is readily miscible with water, which is a tremendous advantage from the point of view of fire risk, and always carries five to ten per cent of water in solution. Steam is instantaneously generated by the heat of the explosion from this water in the mixture, and as it is far cooler at the moment of generation than the walls of the combustion chamber, it tends to absorb the heat that would otherwise have to be taken care of by the water jackets.

The makers of the Hewitt trucks state that their vehicles when equipped with the special alcohol motor and run on that fuel, will show an increase in mileage of fully 20 per cent over that possible with the gasoline motor per gallon of fuel. At the present prevailing prices for denatured alcohol, the cost of running a truck with it is estimated to be approximately $1.25 more per day than with gasoline. Furthermore there is, at present, no stability to the alcohol market and prices for this commodity might unexpectedly rise to a prohibitive figure. This has naturally deterred purchasers from investing in trucks equipped with alcohol motors, as the latter cannot be run on gasoline owing to the higher initial compression employed, which would cause pre-ignition.

Two years ago, the Department of Agriculture undertook an exhaustive investigation of the subject, and as the result of experiments made here and abroad, came to the following conclusions:

Alcohol contains 0.6 of the heating value of gasoline, by weight,

and in the department's experiments a small, single-cylinder engine —designed to run on gasoline—required 1.8 times as much alcohol as gasoline per horse-power hour. This corresponds very closely to the relative heating value of the fuels, indicating practically the same thermal efficiency with the two when vaporization is complete.

By proper manipulation, any engine on the American market today, designed to run on gasoline or kerosene, can be operated on alcohol without any structural change whatever. In some cases, however, carbureters designed for gasoline cannot properly vaporize all the alcohol supplied, and in such cases the excess of alcohol consumed over gasoline, is greater. But the absolute excess of alcohol consumed over gasoline will be reduced by such changes in the design of the engine as tend to increase its thermal efficiency.

By altering the design of the carbureter and increasing the initial compression materially, any engine built to run on gasoline will show an increased thermal efficiency and will then consume less alcohol per horse-power hour in proportion to this increase. An engine designed for gasoline or kerosene will, without any material alterations being necessary to adapt it to alcohol, show slightly more power (approximately 10 per cent) with alcohol than with the fuels for which it was designed, but this increase is at the expense of a greater consumption of fuel. By making alterations designed to adapt the engine to the new fuel, this excess can be increased to fully 20 per cent. Different designs of gasoline and kerosene engines are not equally well adapted for burning alcohol, though all will do so with a fair degree of success.

The storage of alcohol and its use in the motor is attended with much less danger than that of gasoline, and the exhaust from the alcohol motor is not as apt to be quite so offensive as that from a gasoline motor, though an excess of lubricant and imperfect combustion will create an odor when the engine is not properly handled. This is now an important factor in city traffic, as pointed out in connection with taxicab operation, and is daily becoming more so as the number of vehicles increases.

No more skill is required to operate an alcohol motor than one designed to run on gasoline, and the combustion chamber of the former does not show the same tendency to soot up, nor does it, with proper operation, show any effects of corrosion. By reason of greater clean-

liness in handling the fuel, increased safety of storage, and less offensiveness in the exhaust, alcohol engines will sooner or later begin to displace the gasoline motor, particularly when the production of alcohol reaches a scale where its use will be on practically the same economic level. It has been thought that in this field, it would be impossible to conveniently increase the compression of the motor because of starting difficulties, but as the compression release employed for starting on many gasoline motors is equally applicable to the alcohol motor, this should not prove a deterrent.

In many localities, it is unlikely that alcohol power will be cheaper, or as cheap as gasoline power for some time to come, but in isolated districts such as those to which the motor road train is particularly adaptable, the possibility of distilling the alcohol fuel right on the ground would be a decided advantage, both practically and economically. The raw materials ordinarily employed for this purpose are sugar-mill waste (whether cane or beet), cornstalks, any vegetable refuse or similar materials of a very inexpensive nature, it having been demonstrated that it is possible to distill aclohol on a commercial scale from the pine sawdust of the southern lumber mills.

Producer Gas. So far, only the possibilities of employing a form of liquid fuel have been considered, owing to its high value for the purpose per unit of volume, as well as the ease with which it may be stored and carried on the vehicle. Lack of these advantages would appear to make the employment of any form of solid fuel out of the question on an automobile. In fact, coal or coke, as a substitute for alcohol, gasoline, or similar liquid fuels would hardly appear to promise much for the commercial vehicle, whether from the standpoint of economy or convenience. Experience with stationary plants of all sizes has conclusively demonstrated, however, that these two fuels when converted into a combustible gas and used in the internal-combustion engine, are far more economical than any liquid fuel, no matter how cheap, or than the same weight of fuel burned under a boiler and converted into power through the medium of the most advanced type of steam engine.

Hitherto, the size and weight of the necessary apparatus for converting the solid fuel into the gaseous state has rendered its adaptation to the automobile impractical. Four years ago, however, the

problem appeared to have been very satisfactorily solved in Great Britain by the design of a gas-producer which was brought down to such a degree of compactness as to make the entire plant quite suitable for installation in a commercial vehicle of the medium and heavy types. The modifications necessary to adapt such a plant to the confined space, as well as the arrangements required to render its operation easy, will be plain from the description.

Of course, none of the essentials, such as the fuel hopper, air blower, water-feed pump, gas cooler, washer, and water tank have been omitted. The plant is as complete as any used in the largest stationary installations and the method of operation is the same. As employed in the service in question, the producer was installed on a double-decked omnibus equipped with a 40-horse-power, six-cylinder, vertical, four-cycle motor, identical in all respects with those employed with gasoline as fuel, except that the carbureter had been removed and the inlet manifold connected directly with the gas bag attached to the outlet of the producer. The latter is mounted directly in front of the dash of the car and is so compact in design as not to add greatly to its length. The producer consists of a comparatively light malleable-iron casting while the supply of fuel is carried in a sheet-metal tank, or hopper, fitted with large handholes, or openings for rapid refilling with coal or coke.

The producer is fitted with a special grate bottom, an ashpan, and cleaning cover, and above the grate on the side of the producer body, a breach is fitted with a large lid for the purpose of cleaning and lighting the fire. The top of the producer is open to the fuel hopper, the fuel feeding automatically from the latter by gravity as fast as it is consumed. An outlet for the gas in the form of a vertical tube passes up through the bottom, terminating near the top, while an open end is provided, surrounding which is a pendant tube of large diameter, fixed to the top of the inner side of the hopper, this tube being perforated at its lower end. To maintain the draught of air necessary, a small centrifugal blower is installed and arranged to be driven directly from the motor through a ratchet device similar to that used on the starting handle of a gasoline motor, thus permitting it to be rotated by hand when the motor is not running. A similar device is also used on this crank handle, so that when the motor is running, the handle is idle.

In this producer, air is conveyed from the blower to the under side of the grate through light copper tubing, which is used to cut down weight. A spring-controlled relief valve is employed on this tubing to keep the air pressure uniform, while the water supply is maintained by a small, single-acting, ram type of pump, which is also driven by the motor. The cooler is composed of gilled tubes placed vertically, to permit any dirt or grit to fall into a well or sump placed at the lowest part of the apparatus, and in which there is always a supply of water to catch it. As it is necessary to clean and purify producer gas before it can be used in a motor, a washer is always employed. This is formed of a tube fitted with a screen and a set of baffle plates and is maintained partly full of water at all times. The object of the latter is to relieve the gas of all fine dust and grit that it carries in suspension, and to accomplish this the gas is passed directly through the water. From the washer, it passes to a gas bag, which is fed by pressure from the producer, through the cooler and washer to the control valve, this valve being automatically operated by the flexible cover of the gas bag. As the engine draws in a charge, the bag naturally contracts, causing the cover to open the control valve and permitting the entrance of a fresh supply of gas from the producer. The throttle is operated in the usual manner, an auxiliary air valve being fitted to enable the driver to vary the strength of the mixture in accordance with the demands made upon the motor. It might appear from the description that such a plant would necessarily be cumbersome and weighty, but such is not the case. Longitudinally it occupies less than one-fourth the space required for the six-cylinder motor, while vertically, it extends at its lower end to about the level of the axles and at its upper end not quite as high as the dash; the fact that the weight of the complete producer and its auxiliaries does not exceed 250 pounds, effectually disposes of the weight question.

Exhaustive tests were carried out to demonstrate the practical working of the plant, as well as its cost of operation as compared with fuels such as gasoline and kerosene. Two producers were built, one small enough to feed the single-cylinder, 3½-horse-power motor of a small runabout, which serves to show in what a very limited compass the complete apparatus may be accommodated, while the other was fitted to a car having a four-cylinder, vertical, 30-horse-power motor. For actual service, a producer was mounted on the 40-horse-

power, six-cylinder bus mentioned. Coke was used as a fuel and tests showed that to run the latter vehicle, 19⅛ pounds of fuel and two gallons of water were necessary per hour. Coke, of the grade used for this purpose, costs about .3 of a cent per pound placed on the car, making the cost of running a vehicle with an engine of this size approximately six cents per hour, as compared with gasoline at 15 cents a gallon and kerosene at 10 cents, the consumption of liquid fuel on the same car amounting to from two to four gallons per hour. It will be evident that this results in an unusually favorable showing for the producer.

The motor can be started within five to ten minutes from *all cold*, the operation merely consisting of getting the fire under way and supplying air for a few minutes by means of the hand-crank attachment to the blower. After this, the car runs the same as one using liquid fuel. The driver has little additional work to perform than where gasoline is employed, as the mixture is fed and controlled automatically by the gas bag and its valve. During the tests in question, speeds ranging from 3 miles to 40 miles an hour were attained, the supply of gas being steady and under perfect automatic control at all times.

While the foregoing will be of considerable interest as showing the possibilities of solid fuel on the commercial vehicle, it is naturally doubtful if any serious attempt will be made to develop it further while the possibility exists of obtaining ample supplies of liquid fuel of one sort or another at a cost so low as to give the commercial motor vehicle its present inestimable superiority over horse traction. One of the chief difficulties encountered at first in the use of producer gas in stationary plants was the amount of fine dust and grit carried into the cylinders by the gas, despite the washing process, and it is evident that this condition would be aggravated where space and weight limitations restrict the size and efficiency of the washer, the result being a scoring out of the cylinder walls and a loss of motor efficiency. On the whole, it seems quite probable that alcohol will prove the legitimate successor of gasoline once the point is reached when the cost of the former places it at an economic advantage.

TIRES

It may seem strange at first glance, that the matter of providing the commercial vehicle with suitable tires should have presented any problem for the designer to solve. Of all the materials that might appear to be suitable for the tires of a business wagon, rubber is the best adapted to the purpose for a number of reasons. This is frequently but erroneously termed "hard rubber" as the rubber, although usually solid, is not what is known as hard rubber, the latter being a substance that has been vulcanized until it has assumed the closeness of grain of very hard wood. Rubber is preferred for tires, because of its ability to absorb vibration and because of its excellent traction, the latter naturally being its chief advantage.

Steel. From this it will be apparent at once why steel tires have not been employed—first, because they would not provide sufficient traction, and second because the pounding, which they would impose on every part of the mechanism would be ruinous. Steel tires are employed on the Sampson road train, but it will be noted that the driving wheels are equipped with cleats to give sufficient traction and the speeds are low. In addition, the mechanisms of both the tractor and the trailers are of the simplest form, designed to stand the roughest kind of treatment. In view of the nature of the service for which a motor road train is intended, and the character of the country in which it is used, steel tires would doubtless form the only practical solution of the problem.

Wood. Next to steel, wood appears to have advantages in this field, which have not yet been fully realized. Its coefficient of friction with the ordinary road surface is far higher than that of steel and its traction is accordingly much better. It also acts as a deadener of vibration to some extent, though not as valuable for this purpose as rubber. On the score of economy, however, it is vastly superior to both steel and rubber.

So far as the writer is aware, the only instance in which wood tires are now employed, is to be found in the Avery tractor, which is really a 3-ton truck designed to meet practically all the requirements of farm use. In the wheels of the Avery, hard wood plugs are set on end around the periphery of the wheel, as may be noted by referring to the illustration of this vehicle, Page 133. The device

seen outside the wood-tired wheels has been designed especially to enable the vehicle to travel over soft ground, as in hauling plows, and while it also comes into action when the car is acting as a tractor on the road, it is not, strictly speaking, a tire. Wood has also been experimented with in the shape of blocks set on end and fastened in the felly of the wheel, but the fact that such a tire has never come into use would seem to show that is was unable to meet the requirements. The wood plug tires employed on the Avery are said by the makers of that machine, to prove very effective in the service for which they have been designed.

Rubber. No difficulty was experienced in the employment of solid rubber tires on light and medium weight vehicles, and had the commercial car never outgrown the delivery wagon stage, there would doubtless never have been any tire problem. As commercial vehicles increased in capacity, however, the solid rubber tires grew in size to correspond, and trouble was immediately encountered in the use of anything larger than a six-inch tire in one piece on a driving wheel. An eight-inch, one-piece, solid, rubber tire was manufactured for use on the driving wheels of a heavy truck but proved an utter failure. This was due to the fact that solid rubber is practically incompressible —next to water, it is probably the least compressible substance known.

Bearing this in mind, the reasons for its failure as a large single tire will easily be appreciated. Take a 5-ton truck as an example. Loaded, the total weight on the tires would be at least 16,000 pounds, depending on the weight of the vehicle itself. As ordinarily designed, a heavy commercial vehicle carries about three-fifths of the entire weight on the rear wheels, say 10,000 pounds in this case, which probably is very close to the reality. Such a truck, equipped with an 8-inch, one-piece, solid-rubber tire would doubtless have in contact with the road surface at its driving wheels, an area of 8-inch by 2-inch or a total of about 16 square inches for each wheel. As each driving wheel is carrying a load of approximately 5,000 pounds, this means a pressure of nearly 310 pounds to the square inch at the point of contact.

While rubber is not compressible, it is elastic, which many erroneously regard as the same thing. Due to this elasticity, the rubber of the tire in contact with the ground, is forcibly squeezed out. In other words, it is simply displaced owing to the great pressure.

But as neither this, nor the remaining rubber in the tire can be compressed to an appreciable degree, it must go somewhere. Its only escape is from the rim of the wheel altogether and it either disrupts the tire or pulls it off the rim. No form of mechanical fastening that can be devised is sufficient to hold a large, one-piece rubber tire on its wheel, and the idea of employing it in this form has had to be abandoned. The action of rubber under great pressure will illustrate the difference between elasticity and compressibility. For example, the only difference between attempting to compress rubber and a solid rock would be that the former would yield by displacement, if free to do so, as in the case of a tire, which is only confined laterally, while the latter would remain inert until the pressure became sufficient to crush it.

This peculiarity of rubber was allowed for in two ways, first, by splitting the rear tire into two units above a certain size, thus permitting the wave of displaced rubber to bulge laterally to a greater extent than where it was in one piece; and, second, by sectioning the tire, or dividing it into blocks of rubber, instead of a continuous piece. By allowing just sufficient space between the blocks to compensate for the amount of rubber displaced by the pressure, these tires have proven very effective in service. A continuous tire of the Firestone dual or twin type is shown in cross-section in Fig. 108 and the following weights are given by the manufacturers as representing the extreme load per wheel that should be carried on solid rubber tires of this type:

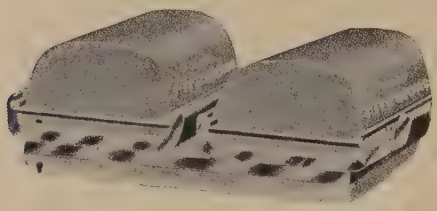


Fig. 108. Firestone Twin, Solid Tire.

For a 2-inch tire, 500 pounds per wheel; 2½-inch, 750 pounds; 3-inch, 950; 3½-inch, 1,375; 4-inch, 1,750; 5-inch, 2,000; 6-inch, 3,000; and 7-inch, 4,000 pounds weight per wheel. In the dual type two 2½-inch tires have a capacity of 1,900 pounds, exceeding by 400 pounds that of two single tires of the same size. Two 3-inch, will carry 2,500 pounds; two 3½, 3,500; and two four-inch—or a *dual four-inch* as it is known—will bear 5,000 pounds per wheel. Firestone tires of this kind are made with cross-bars of steel vulcanized right into the rubber near the base of the tire and made an actual part of it. The tire itself is immovably held in the channel by two

endless retaining wires which press firmly upon the shoulders formed by the cross-bars. These dual tires have such an advantage over the single tire, that the latter is now only employed on the lightest vehicles.

The second and more successful solution of the problem where the very heavy vehicle is concerned, is shown in Fig. 109. This is the

Fig. 109. Kelly-Springfield Block Tire.

Kelly-Springfield block tire and in the form illustrated shows tires appropriate for the front and rear wheels of 5-ton to 7-ton trucks. Each block of rubber is independently fastened by being slipped through an opening in a steel plate corresponding very closely to its size. These blocks have a spreading base of strongly reinforced material, so that when the steel rim is bolted in place they are very firmly held. Four sections of steel rim are employed to each com-

plete wheel. The use of a tire composed of separate blocks not only eliminates the tendency to creep on the rim or jump off altogether—which marked the single-piece, large-sized tires—but it also reduces to a large extent, the internal or molecular action of the rubber, which causes heating and is detrimental to the life of the tire. The space between the blocks not only allows for the expansion or displacement of the rubber, but also gives greater traction, acting somewhat after the manner of a series of cleats, but without the disadvantages of the latter. The block construction also makes the tire much cheaper to maintain and repair, as where a section of a continuous solid tire is accidentally cut or badly damaged, it involves an expensive repair during which the tire must be out of service, while with the block construction, any one of the units may be replaced in a few minutes at comparatively small expense. The metal frame and the rubber blocks are illustrated in Fig. 110.

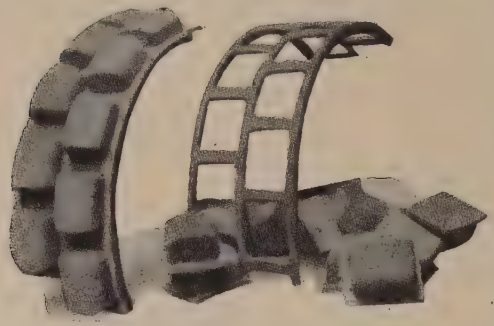


Fig. 110. Metal Tire Frame and Blocks.

A tire of this kind of the average diameter is composed of from thirty to forty blocks, and for carrying weights in excess of a certain load per wheel, are made in dual form on the drivers, the blocks, in this case, being placed in staggered relation, as shown by the illustration. Based upon wheels of not less than 36 inches in diameter, the extreme carrying capacities of tires of this type are given by the makers as follows: For 3½-inch tires, 1,200 pounds; 4-inch, 1,500 pounds; 5-inch, 2,000 pounds; 6-inch, 2,800 pounds; 7-inch, 3,500 pounds; and 8-inch, 4,500 pounds per wheel respectively. Typical equipment for 4-ton and 5-ton trucks would be 4-inch single front and 5-inch dual rear; for 6-ton and 7-ton trucks, 5-inch single front and 6-inch dual rear; while for 10-ton trucks, 5-inch single front and 7-inch dual rear. One of the wheels of a 10-ton Hewitt coal truck equipped with tires of this type is shown in Fig. 111.

MANAGEMENT

The discussion of the taxicab has revealed the fact that the success of a commercial vehicle in service depends to no little extent upon its operation. The designer has made every effort to reduce its mechanism and control to such absolute terms of simplicity that little or no discretion is left to the driver, but it is naturally out of the question to eliminate the personal equation entirely. The electric

Fig 111. Wheel of Hewitt 10-Ton Truck with Kelly-Springfield Dual Block Tire.

vehicle means the closest approach to this ideal and therefore has an advantage where the grade of labor to be employed is in question.

Conditions where the gasoline-driven vehicle are concerned, are quite different, and to this fact has been due, in no small measure, much of the reluctance displayed by business men who were experienced in other forms of motoring, in adopting the power wagon for

their commercial needs. The training of a sufficient number of men to properly handle gasoline trucks has presented a real problem, which has been rendered far more difficult by the lure of pleasure-car service at rates of compensation beyond the standards permissible in the commercial field. Thus, many drivers, once they had mastered the handling of a truck, immediately deserted this field for the much higher compensation of a chauffeur's position, and the process of training had to be repeated, often to the detriment of the vehicle itself. The labor problem is one, however, that will provide its own solution in the course of time.

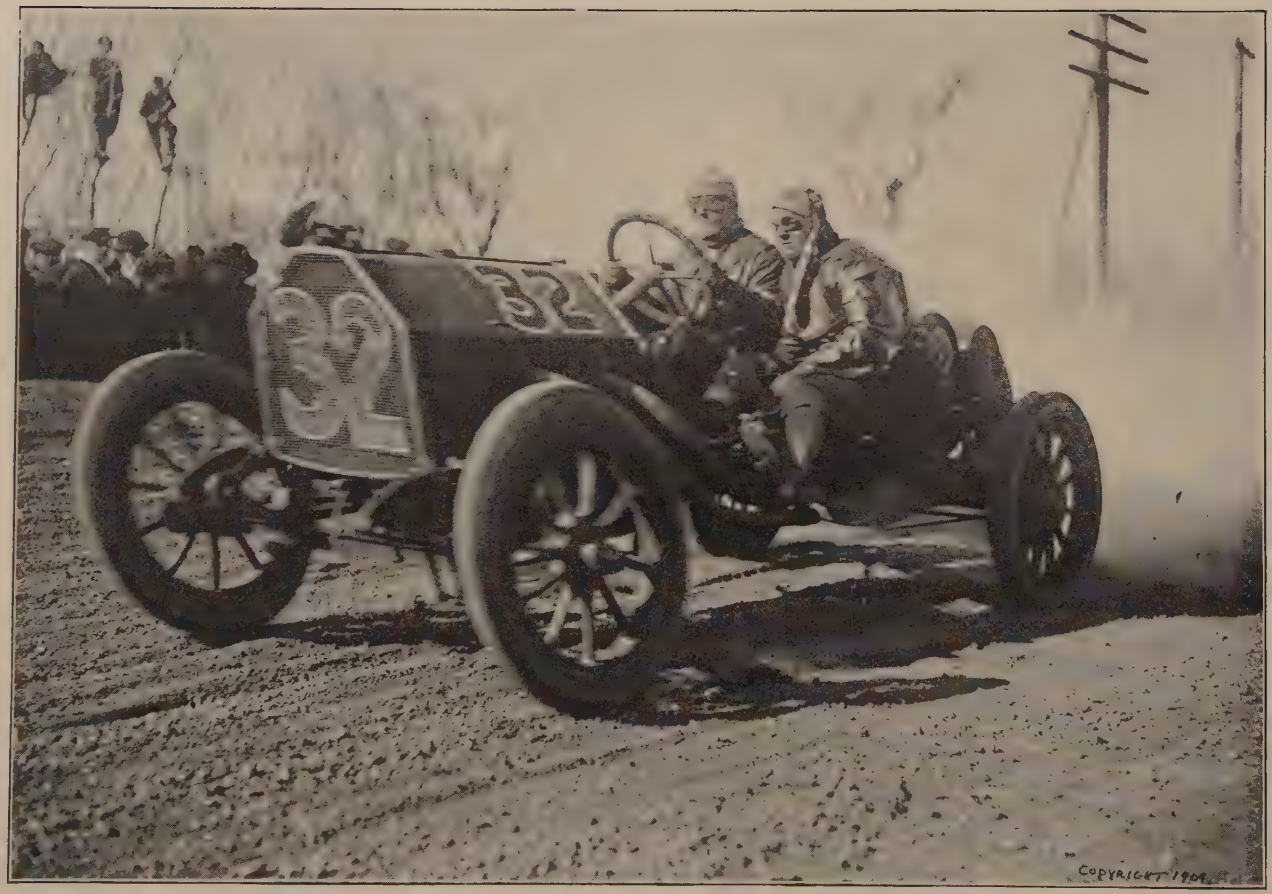
The investment represented by the average commercial vehicle, whether a delivery wagon or a truck, is so much greater than that called for by a horse-drawn unit of the same type, or even its equivalent in horse-drawn equipment, that radically different methods of operation are called for if the overhead expense is to be kept down to a working minimum. In other words it does not pay to permit the motor vehicle to stand idle at all, if it can be avoided. That this is possible to a very large extent is manifested by an ingenious arrangement devised by the Wanamaker delivering service in New York. In common with other establishments of its kind, the Wanamaker store maintains a delivery service extending over a wide radius in and around New York. Near-by deliveries are made direct by the wagons which return to the store for reloading, while outlying districts are served by wagons which receive their loads from a distributing station conveniently located in that district. These distributing stations receive their supplies in large quantities from the store in motor trucks, such as the 3-ton Packard truck, Fig. 112, several of these being employed for the purpose. But as a body of the size shown would take some time to reload or empty of comparatively small packages, false bodies, or crates, have been designed to fit snugly inside the real body of the truck. These false bodies are taken right into the shipping room and packed, ready to be lifted into the elevator and rolled directly into the waiting truck, its return to the store and its departure with a new load thus being a matter of only a few minutes, so that one truck can serve several distributing stations at outlying points.

Where but one or two vehicles are to be maintained, as in the case of the small establishment, it will doubtless be found not alone

Fig. 112. Packard 3-Ton Truck Fitted with a Second or False Body to Facilitate Rapid Loading.

most convenient but most economical to rely upon the services of the public garage for storage, fuel, supplies, and ordinary repairs; it is also a wise precaution to refer any repairs of moment directly to the maker of the vehicle. But where the number of vehicles in the service of a house exceeds five or six, both greater economy and greater efficiency of the service will result from placing them under the care of a competent manager in a garage maintained by the establishment itself. Supplies of fuel and lubricating oil may then be purchased on more favorable terms and a closer check kept on the quantity used by the different cars. Closer check can also be kept of the drivers and their ability to handle the machines.

When a comparatively large number of vehicles is to be maintained, the economy and efficiency will be increased by the equipment of a garage, and a machine shop which is able to take care of the ordinary repairs and provide ample facilities for giving the machines the thorough overhauling to which they should be subjected at least once a year. Motor wagons are so far in advance of horse delivery, even where the latter has been brought to the highest degree of efficiency, as to admit of no comparison whatever. But as the cars are usually purchased by laymen and operated by unskilled labor, many disappointments result from expecting entirely too much. No matter how close an approach to mechanical perfection a machine may represent, it can never be anything but a machine. Those who condemn the commercial motor vehicle after a short trial which, from the user's point of view, has been marred by petty defections of the mechanism, seldom stop to think of the constant care and inspection involved in the up-keep of any machinery.



HARROUN IN A MARMON CAR WINNING THE WHEATLEY HILL TROPHY IN THE VANDERBILT RACE

One Hundred Ninety Miles in One Hundred Ninety Minutes Without a Stop.

PRIVATE GARAGES AND REPAIRS

GARAGES

Public vs. Private Garages. Sooner or later, every car owner, present or prospective, comes face to face with the problem of housing his car in such a way as to be fairly handy, suitable for repair and adjustment work, and in most cases moderate in cost. In very large cities, such as New York and Chicago, this problem is solved in the only possible way, that is, by using a public garage. But in suburban locations and in smaller cities and towns, the convenience, and the low cost of grounds and building, compared to the high cost of probably very inferior public garage work, makes the private garage proposition a very attractive one. Having such a place close to the residence, no time is lost going to and fro, when desiring to use the car or after a run has been concluded. When repairs are needed, they may be done immediately, thus reducing the expense which might be entailed by letting them go for want of prompt attention. The monthly or weekly charge for rent is eliminated, the car is kept better, upkeep and maintenance charges are reduced to a minimum, and other material savings are effected. The private garage, then, places an automobile within reach of a large number of persons.

Many persons have a barn or other outhouse which seems so nearly suitable that a few dollars would convert it into a usable garage. Experience has proved that this will seldom turn out as satisfactorily as the specially constructed building, some later developments showing where the garage would have been more economical or better suited to the work in the long run.

Types. Having decided to build, the next point to settle is the form and the construction material. As far as the latter is concerned, there are about eight possibilities, as follows: (1) wood; (2) steel; (3) wood and steel; (4) concrete; (5) hollow tile; (6) other fireproof types; (7) concrete in combination with any or all of these, as wood, steel, or tile frame with concrete finish and floors; (8) brick or stone, either alone or in combination.

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Fig. 1. Concrete, Metal Lath, and Wood Garage. A Good Example of Semi-Fireproof Construction

Fig. 2. All-Wood Garage with Living Accommodations for Chauffeur

Fig. 3. Hollow Tile and Cement Garage

Doubtless the majority of garages to be considered will come under 1, 4, 7, or 8, but they all represent rather distinct types. For instance, Fig. 1 has a sheet metal (metal lath on steel angles) framework with a smooth concrete plaster covering, while the floor and runway are of cement, and the roof of shingles on wood framing. This represents the semi-fireproof type, walls and floor being strictly fireproof, while doors, window frames, and roof would burn readily. As such, the insurance rates would be much higher than on an all-concrete structure.

In Fig. 2 is shown a garage which is all wood except for the floor and runway, the latter extending the full width of the building

Fig. 4. Artistic Brick and Stone Garage

in front. The forward portion of the garage is carried up a second story for the chauffeur and his family. The building houses three large cars and is well equipped.

An example of hollow tile construction with a thin cement plaster covering is shown in Fig. 3. This holds two cars and provides living rooms on the second floor, similar to Fig. 2. Except for window frames, doors, stairs, and roof, this is fireproof, the hollow tile giving the additional benefit of greater warmth in winter and coolness in summer. As will be shown presently, this material may be used without an interior covering.

A few other types will be discussed briefly. Fig. 4 shows a brick building with very ornamental stone trimmings. This garage

Fig. 5. All-Frame Garage for Two Cars

Fig. 6. Pretentious Concrete Garage with Tiled Roof

will house two or three cars and is provided with double doors to facilitate entrance and exit, always an important feature. Fig. 5

Fig. 7. Frame Garage with Plaster Second Story

represents an all-frame structure, and Fig. 6 one of concrete with a tiled roof and holding three cars. Of all the types so far shown, this

Fig. 8. Fireproof Garage with Concrete Roof

Fig. 9. Excellent Garage of Concrete and English Half Timbering

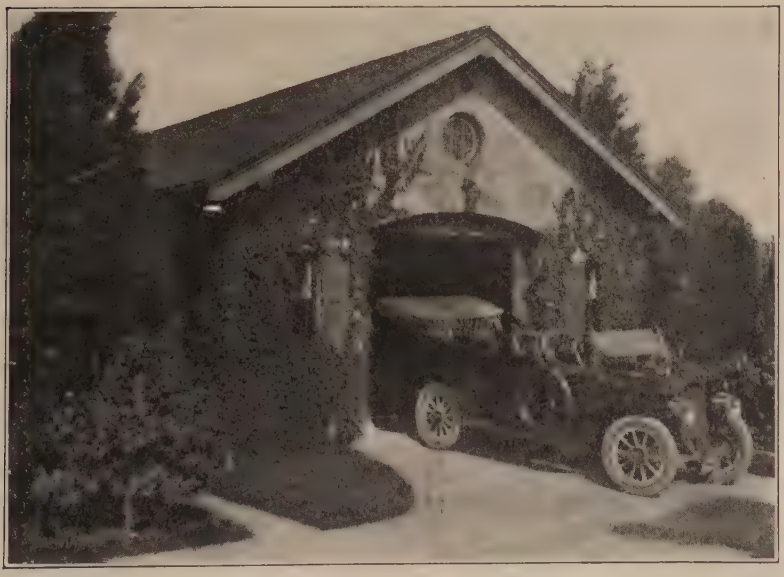


Fig. 10. Concrete Garage in Pretty Setting

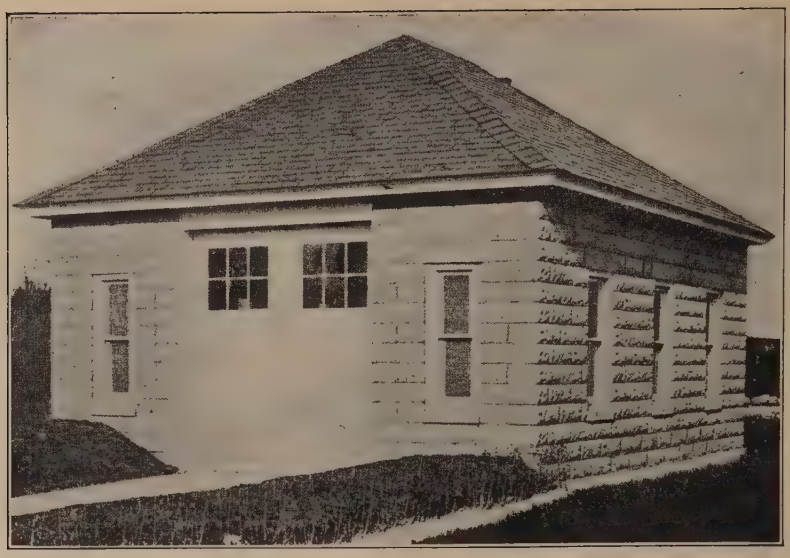
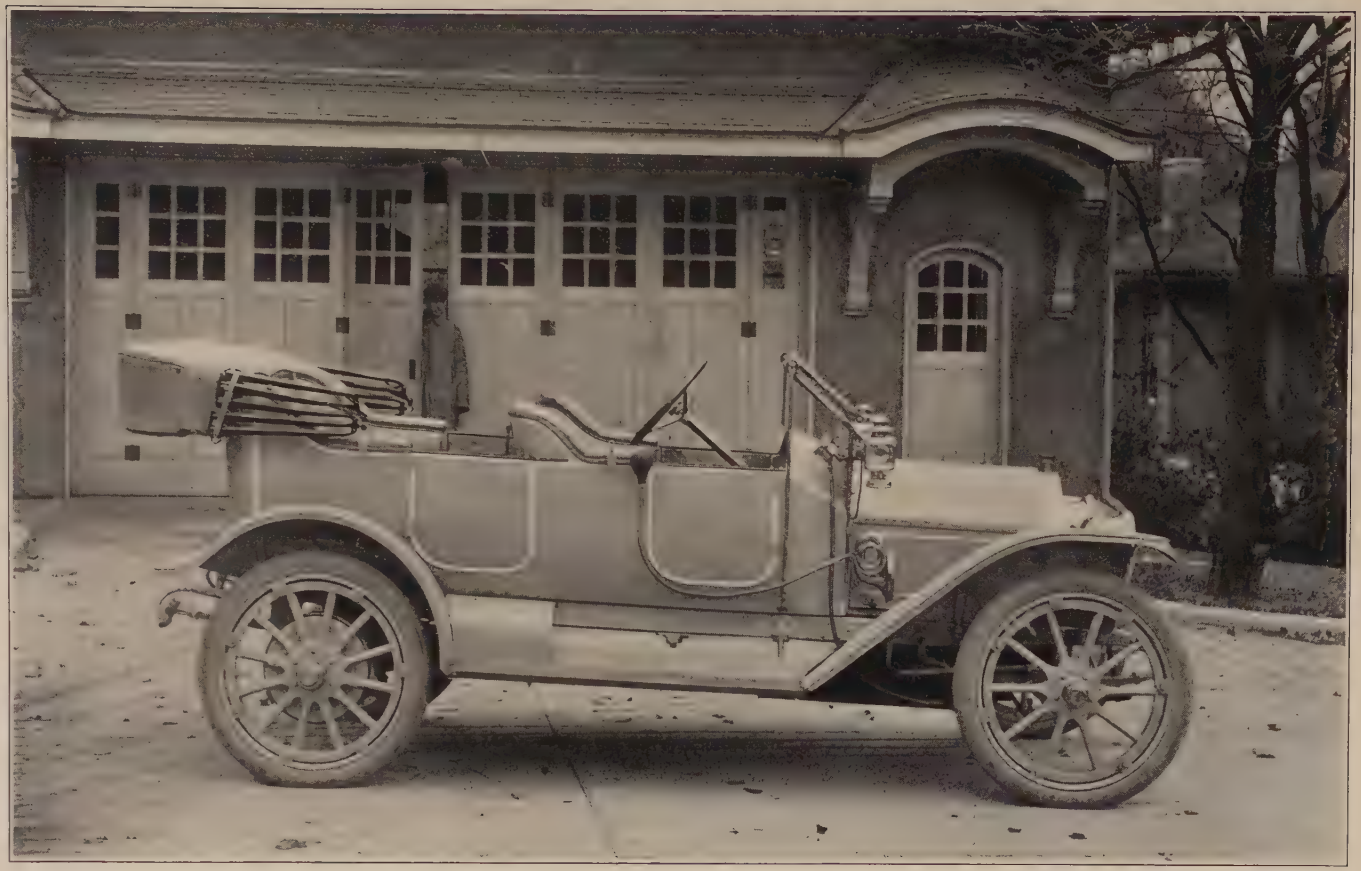


Fig. 11. Concrete Block Garage

Fig. 12. Brick and Concrete Garage of Artistic Design



OHIO FORTY G FIVE-PASSENGER FOUR-DOOR TORPEDO

The Ohio Motor Car Company, Cincinnati, Ohio

is the most nearly ideal from the point of view of fire hazard. Fig. 7 shows an ordinary frame structure with plaster second story which holds two cars. Fig. 8 shows a fireproof garage of concrete on metal lath, built on the Kahn system, the roof as well as the side walls being of concrete. Fig. 9 illustrates the combination of stucco plastering and English half timbering with a concrete and stone foundation wall. Architecturally this is as pleasing in appearance as

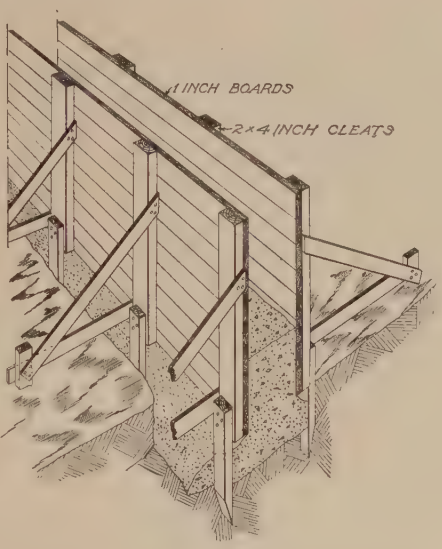


Fig. 13. Construction of a Concrete Form

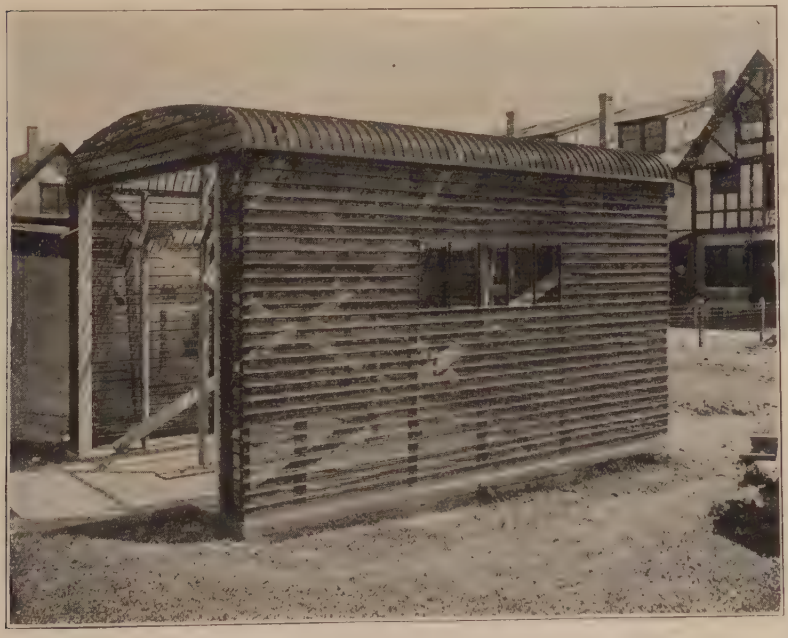


Fig. 14. Metal Lath Frame Prepared for Concrete Garage

any shown. Fig. 10 is of concrete, Fig. 11 is of the same material in block form, while Fig. 12 has a brick first floor and stucco plaster over wood for the second.

Concrete being considered the best material for garage construction, a few words in detail will not be out of place. Concrete may be used either as a plaster over steel or other structure, the thickness of this layer varying with conditions from 1 inch up to 3, or it may be moulded in forms and allowed to set, in the latter case the thickness required being as high as 18 inches.

When used in forms, as many of the latter must be built as the workmen can fill with semi-liquid concrete at one time. Fig. 13 gives the details of such a form, one end being left open to show the foundation and wall thicknesses. Smooth boards must be used, otherwise the resulting wall will be rough.

When metal lath is used on a structural iron framework, Fig. 14, the concrete is laid on like plaster. The illustration shows what can be done for less than $200 including the contractor's profit, the cost of each individual item being given below. The floor plans and arrangement will be presented and discussed later.

Cost of a One-Car Concrete-on-Metal-Lath Garage

568 sq. ft. of No. 24 gauge lath at 6 cents per foot	$34.00
535 pounds of structural steel at 5 cents per pound, ready for erection	26.75
3 windows, with 12×20 glass 1 light high, 5 wide	14.00
Total materials cost	$74.75
Floor 3 inches concrete, 1 inch finish	$16.80
Erection of structural steel and Hy-Rib, labor only	15.00
Wall plastering, 2 inches thick, roof 2½ inches	65.00
Door, 1¾ inches thick, including hanging and hardware	20.40
Glass and glazing	2.80
Total work and accessories cost	$120.00
Grand total of entire building, including contractor's profit	$194.75

The interior of the hollow tile garage, which is shown complete in Fig. 3, is brought out in Fig. 15, the wall surface being formed by the tile themselves, without the aid of plaster. In the foreground may be seen the drain, while just above it will be noted the washer and the electric lights. This building shows an important advan-

Fig. 15. Interior of Fig. 3 Showing Plain Tile Finish

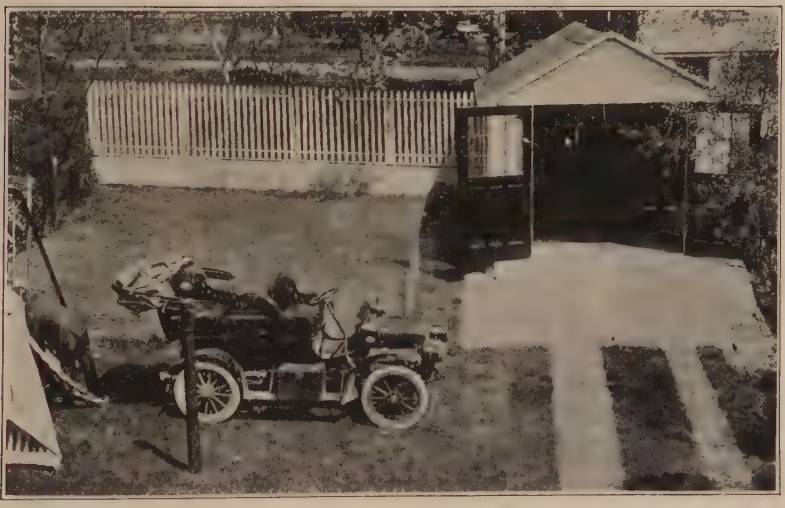


Fig. 16. Convenient Back-Lot Garage of Simple Construction

tage in garage construction, namely, the superior utility of length as compared with width.

One-Car Designs in Detail. *Long Type.* The majority of garages are of the one-car type, although occasionally it happens that neighbors get together and build a common structure, or else one man builds large enough for three or four, and rents space to his neighbors. Fig. 16 shows what may be done with the back of an ordinary suburban lot. Here a small garage of wood has been erected at the extreme rear, with a washing platform and runways

Fig. 17. Floor Plan of a Garage Showing Turntable

of cement, the whole being surrounded in a pleasing manner by vines and trees. While the building is not large it saves the owner many a long walk to and from the nearest public garage as well as considerable money in the course of a year.

It will be noted that its size will allow only room for the car and for a passageway 2 feet wide on each side. Such a scant amount of space is seldom advisable if the owner figures on doing his own work, in which case the design should include a well-located workbench and a full stock of tools. The floor plan shown in Fig. 17 really represents the plan of Fig. 8 and of Fig. 14 slightly modified. In this drawing the writer has included an extra window on each of the

long sides, making this change because of the large number of garages he has seen which were planned with too little light. As a matter of fact, when the car is in the building and is blocking off the big double doors at the front, and usually the one side window also, some unobstructed window light is absolutely necessary.

A workbench has been included at the rear end, with a large window over its middle, and a turntable near the center of the floor. The floor space of this garage is sufficient to allow turning a car, so that it may be driven in front end first, and then turned around so as

Fig. 18. Square Type of Garage of Concrete Construction

to leave in the same manner. The frequent accidents caused by backing out or into the building are thus avoided, and washing and repair work are made much easier.

Square Type. The neat little concrete garage shown in Fig. 18 is more nearly square in shape than those already shown. This brings up the question whether the square or the long type of equivalent area is preferable. Some hold that the short, nearly square shape presents the most advantages, since everything is close together; others believe that the long, narrow shape has many advantages over the square form.

For this reason two sketches of typical floor layouts, Figs. 19 and 20, have been prepared. The former measures 17 × 18 feet,

and its inside area about 283 square feet, while the latter, measuring 14×22 feet 6 inches, has about 295 square feet of floor area inside, a difference of about 4 per cent. At a glance the longer one shows more working space, although, to be perfectly fair to the square type on this point, the turntable in Fig. 19 should be as close to the front door as in Fig. 20.

As to window space the two types are about equal, the extra back window and the two small front windows in the square

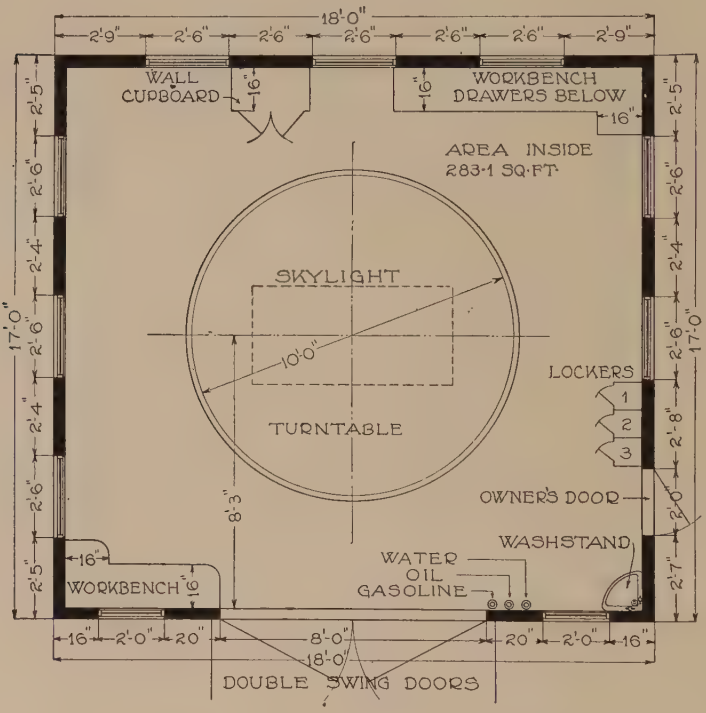


Fig. 19. Floor Plan of Square Type of Garage

type being offset by the larger number of windows which can be used on the sides of the long type. When working on a dismantled car, however, for occasional repairs or during the spring and fall overhaul, the design of Fig. 20 gives more open area at the back, clearer bench room, and freer window space.

Portable Form. It would not be quite fair to dismiss the one-car garages without mention of the portable form. This type, an

excellent specimen of which is shown in Fig. 21, has the attractive feature to the busy man of being sold ready for use by its makers. The one shown is 12×18 feet inside, and is made in sections. To the man who does not own his home, it solves one highly important point—that of the disposition of his building should he move. A portable garage is simply dismantled and erected at the new quarters, none the worse for the change.

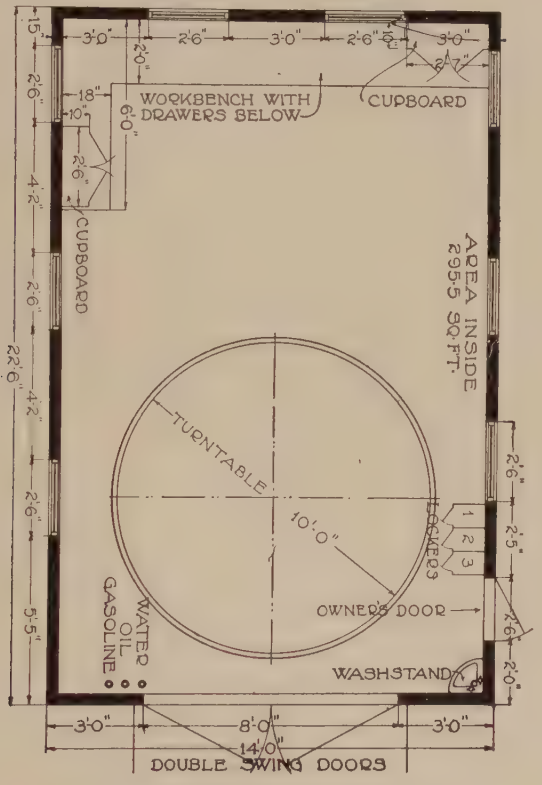


Fig. 20. Floor Plan of Long Type of Garage

Two- and Three-Car Designs. Turning next to the garages which are built primarily for two or more cars, and which in the main are more commodious and better appointed throughout, there enters for the first time the consideration of the quarters for the driver and his family. Sometimes, although the construction of the building may be very elaborate, the element of convenience and

adaptability has often been ignored entirely. Such, for instance, is the garage shown in Fig. 22, the plans for which may be seen in Fig. 23. The building is two stories high, the second being given over to living rooms entirely. Even on the first floor, the coal storage, furnace, storeroom, entry, stairs, and charging room for batteries take up more than one quarter, so that, of the total area, the cars have less than three eighths. In considering this design, it will be noted that aside from the double front doors, there is little provision for light. The car room, measuring 25×30 feet—that is, 750 square feet—has only four windows, all small and all at one end. The rear of this

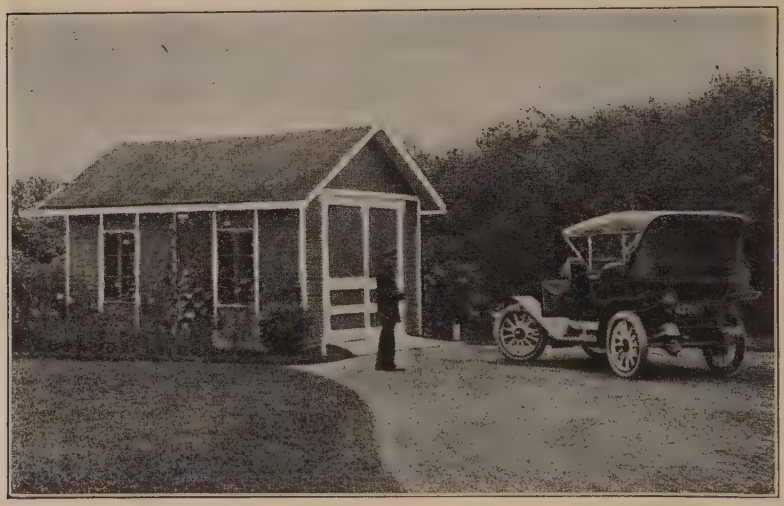


Fig. 21. Portable Type of Garage

room has no windows, nor has the repair room, with its pit, any light except when the doors to the store and charging rooms are left open. A better arrangement could have been effected by placing the coal and charging rooms in the center and the repair room with pit on the corner.

Almost as bad in this respect is the English garage, Fig. 24. where three tiny end windows, over 40 feet apart, and as many skylights some 20 feet in the air, are depended upon to illuminate the whole interior of a building measuring 30×46 feet. This garage has steel roller blinds for the entering doors, so that with these closed no light can be expected from that side as might be the case with wood paneled and glass forms.

An improvement over both may be seen in Fig. 25 which is of field-stone construction. Although it houses but two cars, it is

Fig. 22. Example of Pretentious Private Garage with Bad Interior Design

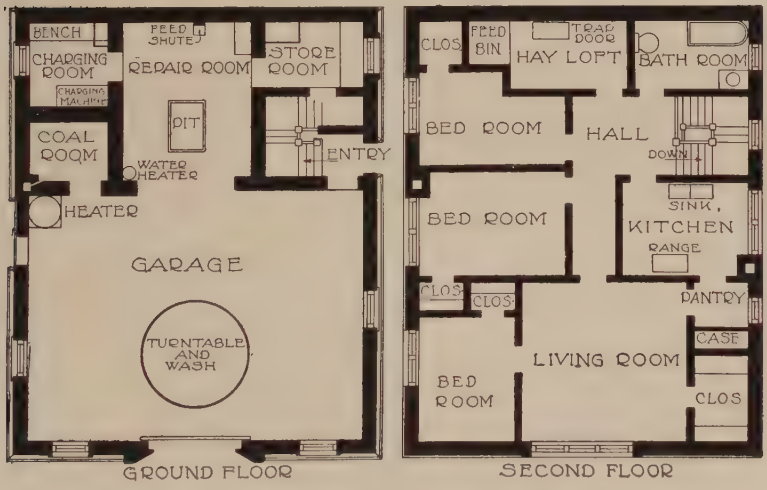


Fig. 23. Floor Plans of Garage Shown in Fig. 22

sufficiently large for three, having interior dimensions of 20×30 feet. The interior has a wash stand and lockers at the entrance on the right. At the back, on the same side, are a forge, anvil, drill press,

and other tools. In the middle of the rear side is a large fireplace, while the entire left side is taken up with a wide workbench which

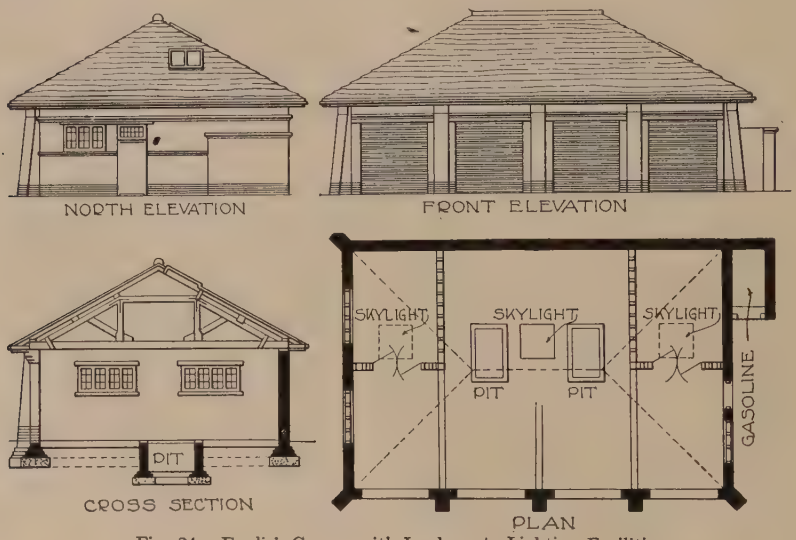


Fig. 24. English Garage with Inadequate Lighting Facilities

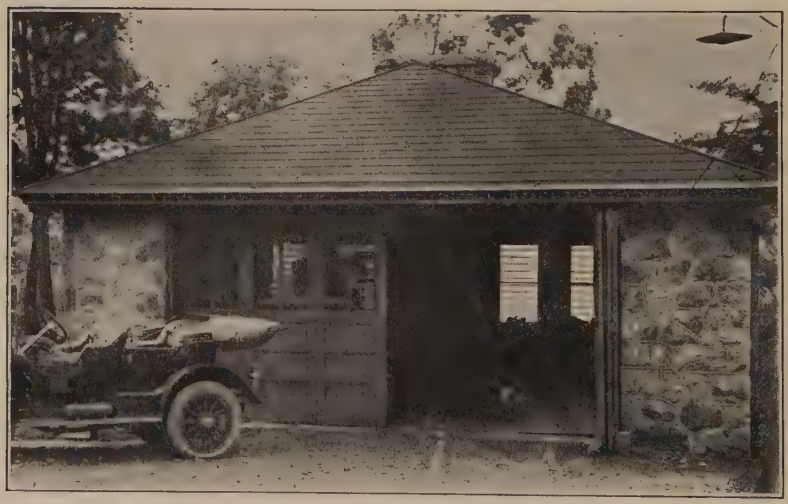


Fig. 25. Stone Garage of Good Construction

runs from front to rear. The doors are double, each half folding up into three sections. When all are folded back, practically the

entire front of the building is open. For lighting there are four rear windows, which are visible, and two on each side, while it will be noted every section of the doors carries a large pane of glass.

A design of a one-story garage having chauffeur's quarters has already been shown in Fig. 10. The ground plan is shown in Fig. 26. This is large enough for two cars, a big workshop being provided in one rear corner where there is plenty of room and light, while the size of the building allows of a very comfortable home for a single driver. Entrance is by double door, with place for washing both cars at once. Near the door is placed a supply of water for filling the radiator, and also the gasoline and oil supply pipes. In case repairs are needed, it is possible to drive directly into the workshop, over the pit, and start work on the car immediately. Where any work must be done under a car, either a pit or a substitute for one is a necessity.

General Equipment. In the planning of the general equipment of a garage considerable stress should be laid upon lighting, heating, ventilation, water supply, drainage, and similar items.

Lighting. The necessity for plenty of window space has been dwelt upon at some length in individual cases already discussed, so nothing more need be said except that it is impossible to get a garage interior too well lighted. In fact, were it not for the matter of warmth in winter, it would be advisable to build the walls or at least the roof of glass. Skylights are excellent, the light from above appearing to have more illuminating power than that from windows, in addition to which it is more difficult to cut it off. In the way of artificial illumination, electricity is the preferable form, since gas, kerosene, and practically all other lamps, present an open flame, which, in the case of a gasoline leak, may cause an explosion.

Heating. Heating is generally neglected, but the man who has overlooked it and then been obliged to work on the car for several hours during a winter day, will agree that this equipment is important, even though it be only a couple of portable oil stoves. Any kind of stove with open flame is dangerous, however, where so much gasoline, oil, and other highly inflammable materials are handled, hence the source of heat should be either steam, hot water, or hot air, with the fire located outside of the building, or else partitioned off from the main garage.

Ventilation. Ventilation is doubly important in a garage for,

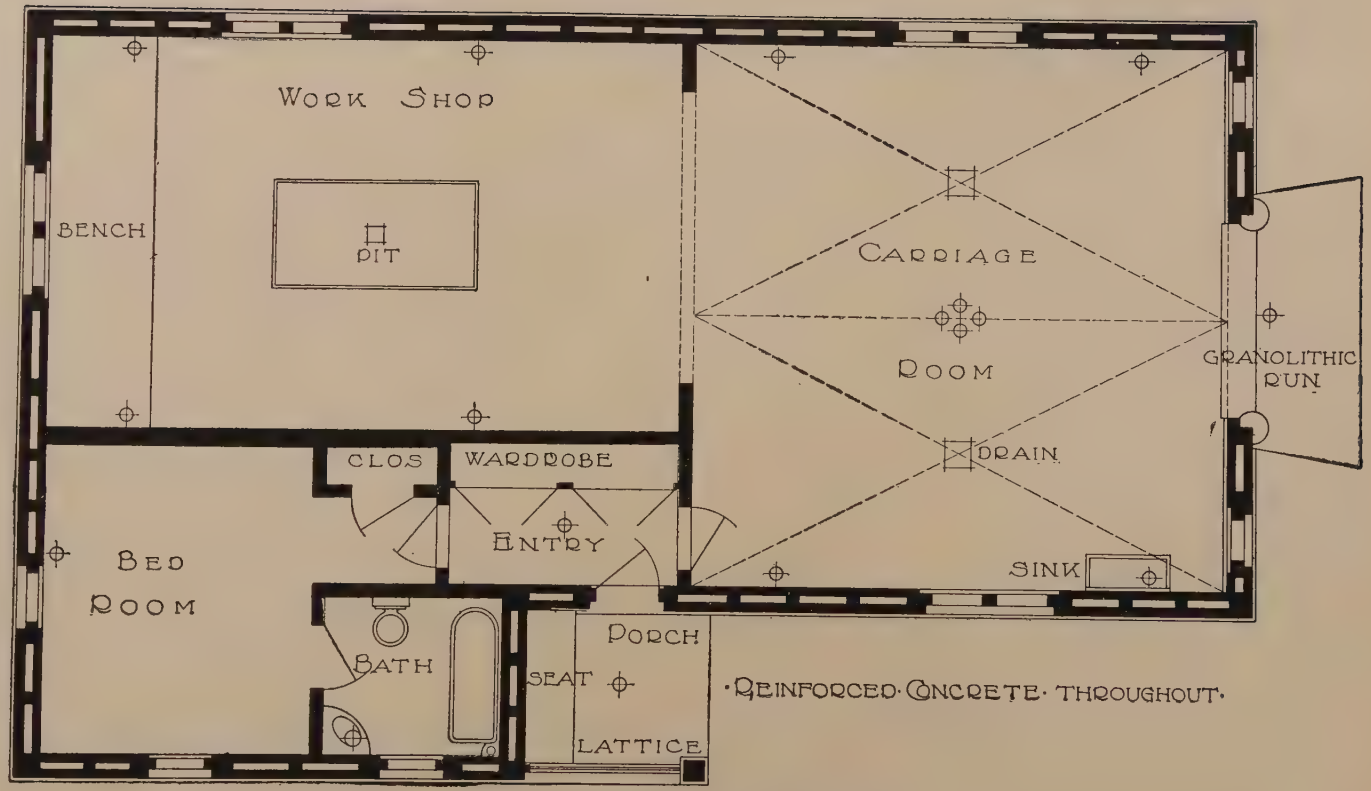


Fig. 26. Floor Plan of Garage Shown in Fig. 10

despite the fact that gasoline liquid is very light, its vapor is heavier than air. The vapor, therefore, falls instead of rises, as one might suppose and the inflammable fumes lying along the floor as the result of spilled fuel are a source of danger for a long time. A garage should always have two openings for ventilation, one placed near the ceiling or roof, and the other close to the floor. This will take care of all possible cases, and if the openings are made large enough, a constant draft will be maintained which will keep the air inside pure and free from all dangerous gases.

Fig. 27. Heating Arrangement in Garage

Water Supply. Water supply in the city is no problem at all, simply a matter of running a pipe from the house to the garage with a suitable faucet, but in suburban or country places, it is not always as simple. Wherever possible, there should be at least two connections for running water within the building, one for washing purposes, and the other for general use. In addition, it is well to provide a method of heating water for use in winter. If the car be used the year round, as is usually the case, it is decidedly inconvenient to wash it with cold water during the months of December and January.

This convenience may be provided in conjunction with the heating system for the building, Fig. 27 showing a furnace which supplies hot water to a series of radiators arranged upon the walls, comparatively close to the floor, as well as to the overhead washer. The result is that the owner has not only a comfortable place to work at all times, but a car which is well kept.

Drainage. The matter of drainage should have early attention. A proper drain is one which will pass the water and other liquids out to the sewer but will retain the more inflammable gasoline. This separation is effected through the ability of gasoline to float upon water and other heavy liquids. As in the form shown in Fig. 28, the outlet is covered by a depth of water, which acts as a water seal. The open space above the liquids, on the other hand, is connected by means of a vent pipe to the roof or other place where the gases which form may pass off harmlessly. When the water accumulates to the depth of the outlet, a quantity will siphon off from the bottom, not the top. As soon as the lower edge of the vertical partition is reached, air will enter, the flow will stop, and the gasoline will remain in the drain.

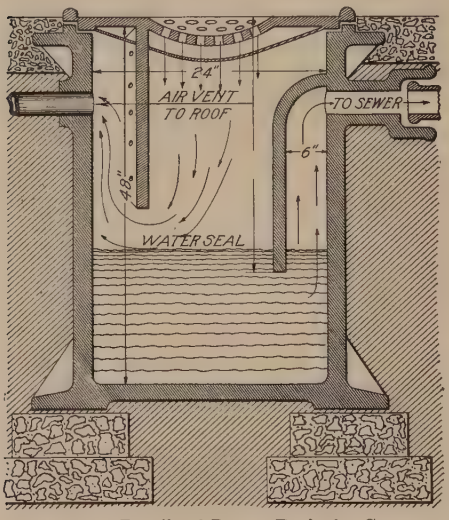


Fig. 28. Details of Proper Drain for Garage

Source of Power. In constructing a large garage, it is well to consider the subject of power, and make some provision for it. This may be done by suspending an induction motor from the ceiling, belting it to a line shaft, suspended from the same, with suitable belts and countershafts for the individual tools. If the house is of concrete, bolts may be set into the ceiling at the time of building, even though no immediate use for them is planned, thus saving a great amount of work later.

Oil and Gasoline. Little need be said of the handling of oils

and gasoline, since it is now so generally understood that the only way to handle either gasoline or oil is by means of tanks. When everything is considered it will be found more economical, more safe, and more convenient, to purchase some well-known system in the desired size.

For those who desire to install their own system the following is suggested: A seamless steel tank *C* with three outlets, one large for filling purposes, and buried in the ground about as shown in Fig. 29, should be obtained.

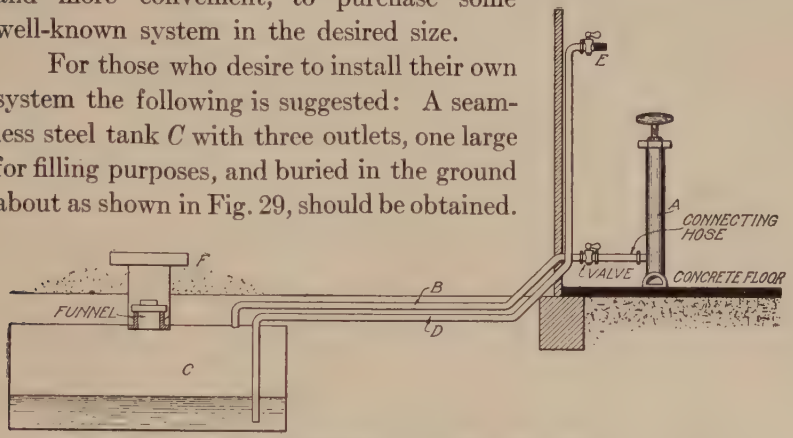


Fig. 29. Arrangement for Outside Fuel Tank

Next a supply of galvanized iron pipe of comparatively small diameter should be secured and attached to the tank. The two pipes proceed, one pipe *D* from the bottom of the tank into the building, and up to such a height *E* as would be convenient for drawing off the fuel; the other pipe *B* runs from the top of the tank to a source of compressed air, such as may be supplied by an old bicycle pump *A*. When there is fuel in the buried container, it is only necessary to open the air cock and pump a little on the foot pump. The pressure in the tank will then force out the fuel at the other pipe when the cock *E* is opened. When not in use, both cocks should be closed. The tank should be buried below the frost line and the filling cap *F* should be so arranged that it can be locked.

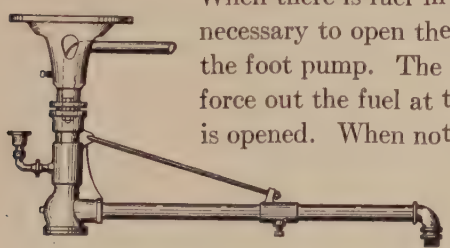


Fig. 30. Ceiling Washing Appliance

Washing Apparatus. An overhead washer is admitted to be the best form and one which can be easily made as shown in Fig. 30. This is constructed from ordinary water pipe, preferably galvanized, and various standard fittings, only two special fittings being needed, viz, a swivel joint, without which the apparatus could not turn, and a special fitting to which the brace is attached. The top portion is

only a form of protective hanger, inside of which the feed pipe is attached by an elbow joint, to which the vertical member is screwed. The whole arrangement is susceptible of considerable simplification, even over that illustrated.

Turntable. One of the drawbacks of the small building has previously been mentioned, viz, the necessity for backing the car in or out. This may be avoided by installing a turntable, the car being

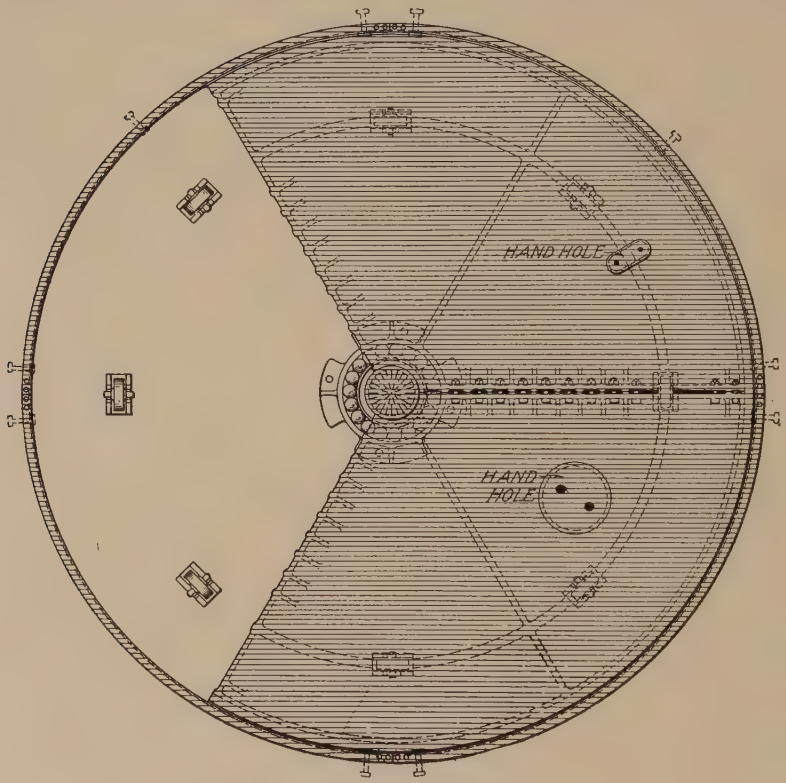
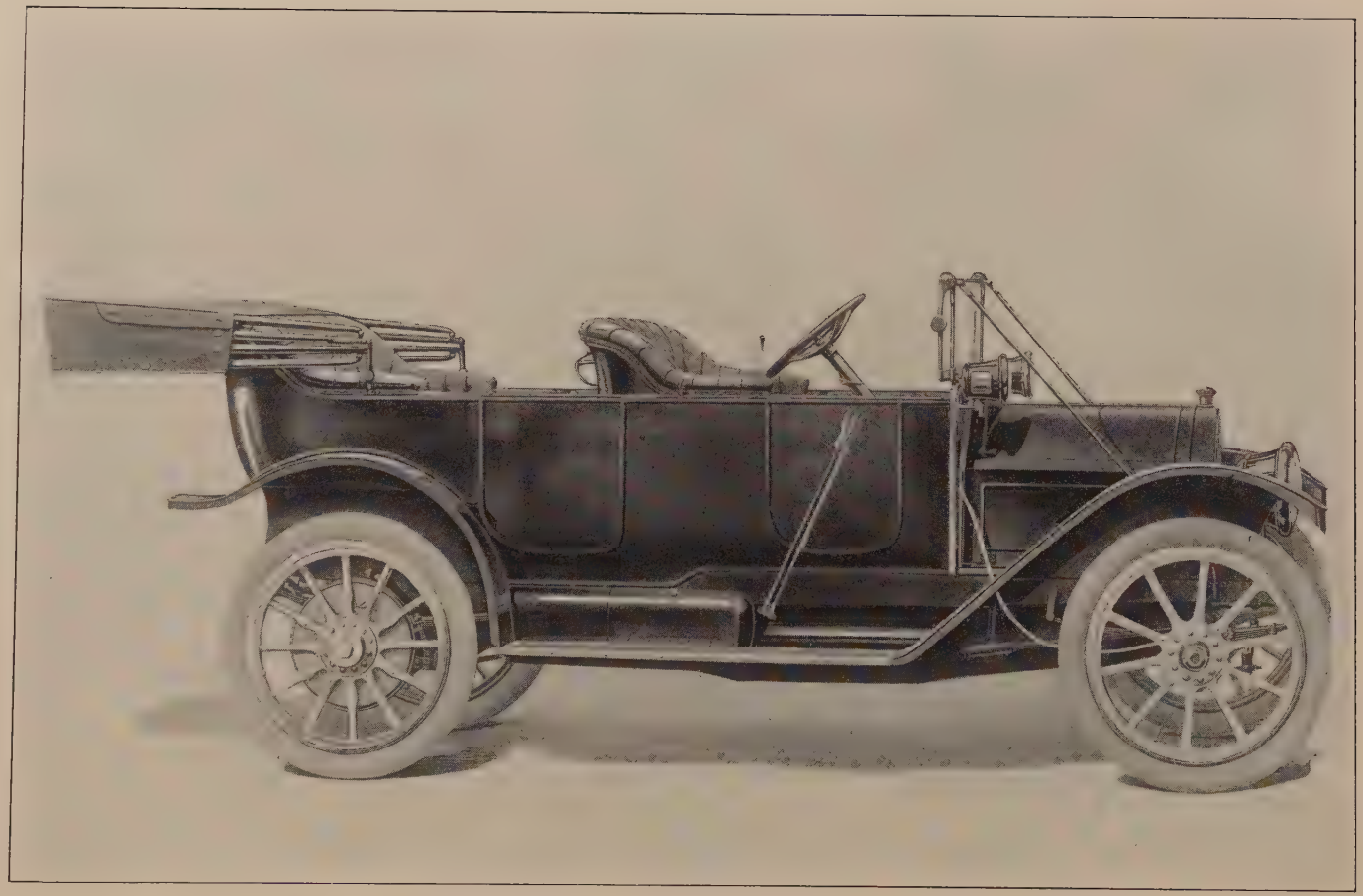


Fig. 31. Garage Turntable

turned around on this, so as to enter and leave facing forward. An excellent form of turntable is shown in Fig. 31. The turning portion is mounted on a central row of very large balls, supported on a raceway. Farther out are set eight rollers, upon which the table will roll if the load is not exactly balanced. When properly balanced the whole may be turned on the balls with little or no effort.

There are numerous advantages of a turntable other than turn-



CADILLAC FIVE-PASSENGER TOURING CAR

Cadillac Motor Car Company, Detroit, Michigan

ing the car around, for example, it allows a greater amount of floor area to be utilized; it facilitates the handling of the machine when washing; and it enables one to easily turn the car so as to get the best light on a particular part which needs repair.

Supply Cabinet. One of the things to be learned at the outset is that the automobile has from 2,000 to 3,000 separate and distinct parts and that if these are spread about promiscuously they will doubtless get mixed up, mislaid, or lost. To avoid this occurrence, a systematic and orderly method must be followed, as, for instance, the use of boxes for all parts which are removed, each properly marked, and for the smaller units, a cabinet like that shown in Fig. 32. The latter is a small cabinet of octagonal shape, pivoted on a central spindle so that it may be turned. A total of 96 compartments are available for the smaller parts, as well as for screws of the various sizes, nuts, bolts, cap screws, cotter pins, lock washers, and the innumerable odds and ends which accumulate as time goes on and which so often furnish the one thing needful to the desperate repair man at the proper moment.

Fig. 32. Useful Revolving Cabinet

Tools. In planning his garage the car owner should not forget that there is something to be done besides build the house. The equipment of small and machine tools should be fairly complete if the maximum saving in repair charges is to be made. It will be wise, therefore, at the outset to have a very close estimate of cost made for building alone, and then apportion the balance of the available funds to tools and equipment, calling upon some experienced friend for a list of requisite tools, and obtaining an estimate of their cost from a supply house. Many men have divided the available money

in two equal parts, one for the building, the other for its equipment. Although this seems like an extreme, the tools are certainly necessary and do not come with the car. For example, the list should include vulcanizer, power air-pump, set of drills, taps, reamers, set of wrenches, wheel pullers, set of files, voltmeter, ammeter, hydrometers, drip pans, funnels, waste and waste cans, gasoline and oil storage tank, tire and rubber tools and supplies other than vulcanizer, hack saw and blades, various punches, chisels, scrapers, wrenches, pliers, screw drivers, and valve lifters.

Fig. 33. Machine Shop a Necessary Feature of the Garage

If one is limited as to funds, he has the choice of spending it all on the garage and buying no tools immediately, but laying in a supply gradually later on as the necessity for them arises, or of dividing the money between the garage and tools in some such ratio as will enable the handling of repairs right from the start. The writer favors the latter plan, with the division about 75 per cent for garage and 25 per cent for tools.

Mention has been made of the provision of a power motor and shafting for running such machine tools as would be useful or necessary in a small shop. Fig. 33 represents a good arrangement

of tools, including lath, drill press, forge and anvil. With this fairly inexpensive combination, any small job on the ordinary machine can be handled with pleasure and profit.

Considerable diffidence is felt about advice on the subject of small tools, because of the wide divergence of ideas on this subject. Some amateur owners have upwards of 200 tools while others get along and keep the car in repair and good running order with 20. Each man must decide in which class he belongs and purchase his tools accordingly.

Below is given a list of tools and equipment as an example of what the owner of an old car considered necessary.

Tool and Material Equipment

Block and tackle	$ 3.50
Fire extinguisher	16.00
Wiring garage	10.50
Vulcanizer	20.00
Two jacks	6.50
Complete set of tools	15.00
Grease and oil gun	4.50
Rubber hose	7.50
Overalls and jacket	1.50
Drip pan, 3×3 feet	1.35
One piano dust brush	.75
Two whisk brooms	.75
One broom	.25
Camp stool	.50
Two-gallon can for oil	.30
Three 5-gallon cans for gasoline	1.50
One long stem oiler	.75
Three short stem oilers	.75
Bucket	.40
Pressure gauge (tires)	3.50
Large funnel	.50
Oil funnel	.50
Glass funnel	.35
Supply of porcelains	1.50
Two pieces of chamois	1.50
Large sheep's wool sponge	1.50
Box waste	1.00
Odds and ends	7.50
Total	$110.15

A full page of tools is shown in Fig. 34, from which the amateur worker may make his choice. The outfit should contain two hammers, one light to carry in the car, and a heavy one to have around

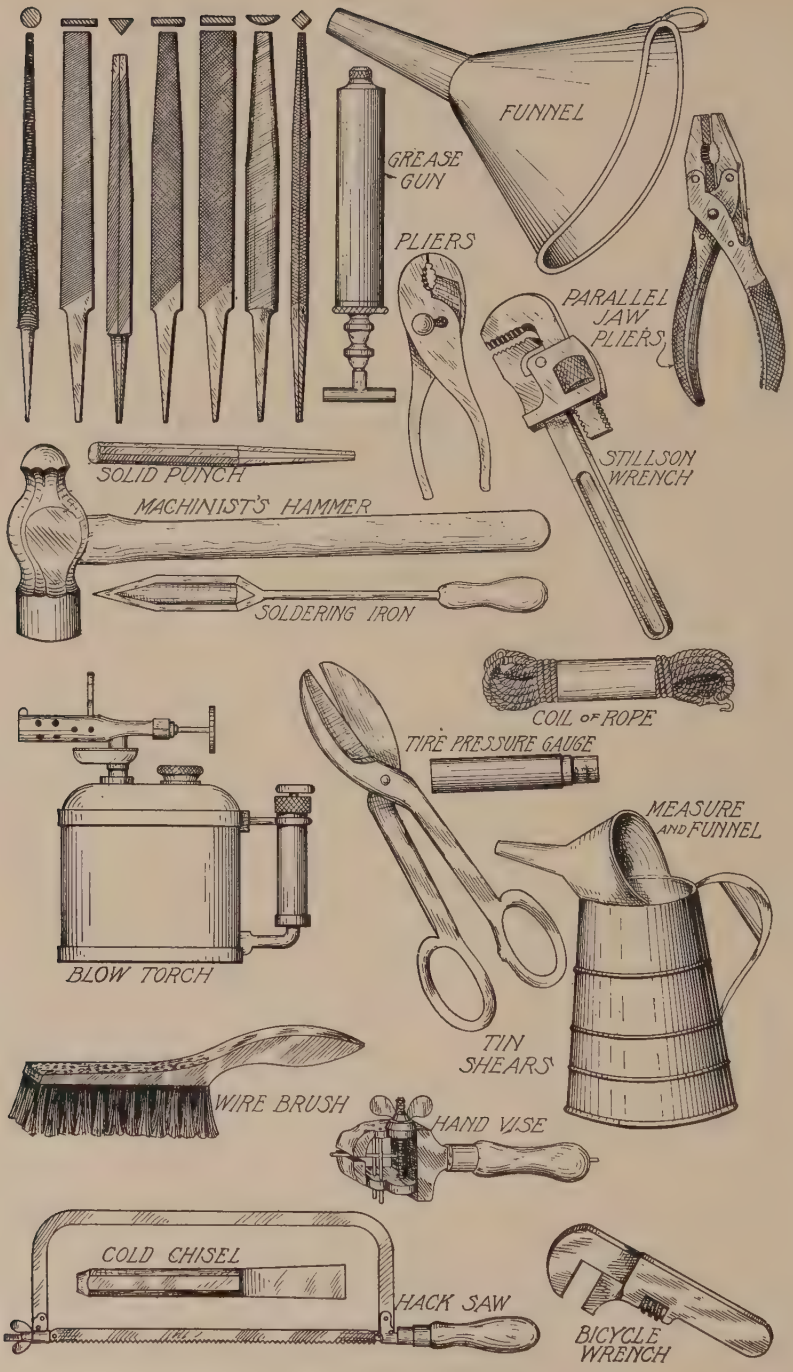


Fig. 34. Necessary Tools for Garage

the building; the set of files should be complete as to shape, grade, and size, those shown being for shape only; the hack saw is a hand tool, to be replaced by a power-driven affair if the work warrants it; and the torch is needed with the solder, and many times is useful in taking off stubborn nuts or bolts.

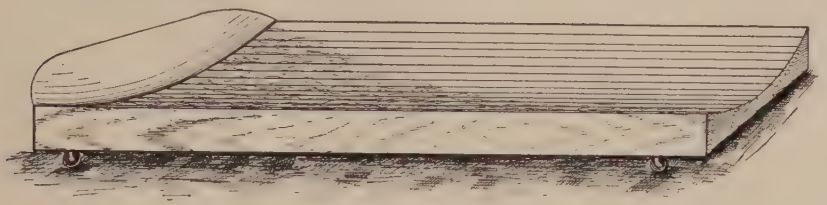


Fig. 35. Homemade Creeper

Fig. 36. Homemade Truck

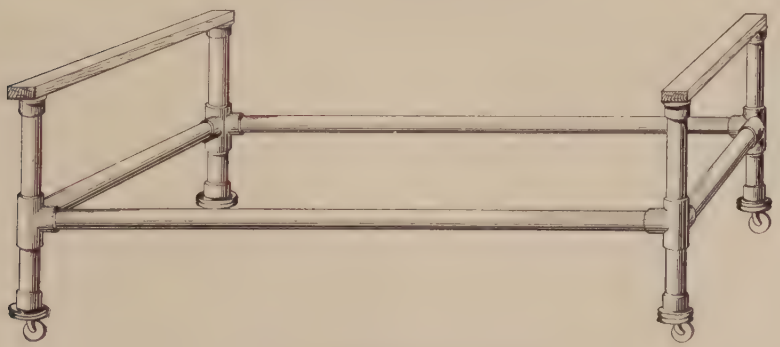


Fig. 37. Homemade Chassis Support

Homemade Equipment. There are a number of useful things in the tool line, which any one so disposed can make. Thus, for working under the car a creeper, Fig. 35, is almost a necessity unless the garage includes a pit or a substitute for it. The creeper consists of a wood frame with casters at the four corners and longitudinal slats as a floor. A pillow or rest may be made for the head if

desired. Figs. 36 and 37 show a couple of stands which are useful in handling parts of the car when disassembling or reassembling it. Fig. 36 is heavier and is used for moving engines, transmissions, or axles around, while Fig. 37 is for holding a body while the chassis work is in progress.

Lifting heavy bodies to a considerable height by means of the small jack usually furnished with the car, is very laborious. To offset this, a quick-lifting jack may be made, as outlined in Fig. 38. This is nothing but a lever of the first class, which has a suitable base. The latter is made from a piece of 2×8-inch hard wood, into which are let a couple of 2×4-inch side pieces, preferably, also, of hard wood. The space between the uprights then would be 4 inches, into which should be fitted a long handle. It is evident that the

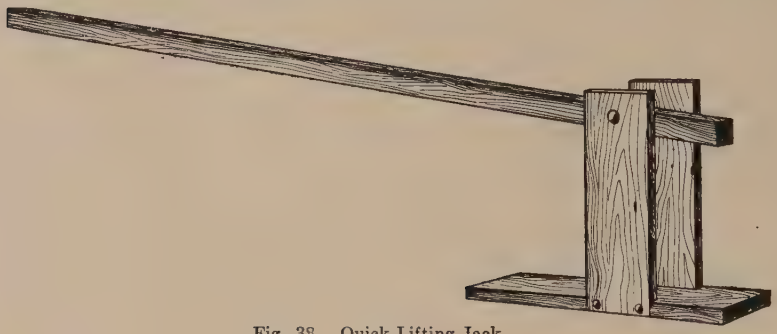


Fig. 38. Quick-Lifting Jack

longer the long arm is, compared to the short arm, the greater the weight which one man can lift. One which was seen in a public repair shop and garage was not less than 8 feet long, the forward projection being about 16 inches, which gave a five to one leverage. With this, one man would lift the whole rear end of a car from 6 to 10 inches in less time than it takes to tell it.

The ingenious man will think of many similar time- and labor-saving contrivances which he can make. For example, the writer has found it an excellent idea to build four small but very sturdy sawhorses, two 14 inches and two 16 inches high, just high enough to allow the tires to clear the floor when these are placed under the axles. The use of these saves the time of the jack so much that they are in use practically all of the time.

Another good idea is a dark room or winter box for the tires.

This should be square, larger on each side than the tire diameter by, say, 2 inches, and in depth an inch or so more than four times the tire section; that is, for 30×3-inch tires, the dimensions should be 32 inches square and about 14 inches deep. This should be lined with a dark felt or some similar heavy material of dark color, and fitted with a hinged and locked cover. It should be placed in a dry place, or if this is not possible, should be set up on legs so as to raise it about $2\frac{1}{2}$ feet off the floor.

General Instructions. In starting the work of disassembling the car, a few general rules should be laid down and rigidly followed. First, never remove a part whose location can possibly be mistaken, or which can be put back in a wrong position, without marking it. Second, always find out from a catalogue, instruction book, dealer, or friend, how a particular part is fastened on before trying to force it off. Third, do not get impatient if the piece does not loosen with the first application of force; try again and again. Fourth, use plenty of lubricant at all times, and don't be afraid to dip your hands into it; aside from washing off readily, it will actually make your hands softer.

The wisdom of the first caution is noted in the case of the timing gears, which must be in exact position relative to one another. If they are not already marked the car owner must do it, or else, when he comes to assemble, he will be obliged to go through the process of retiming, a long, tedious, and difficult job. A few minutes work with a hammer and prick punch will prevent this and insure exact timing. As to the second caution, if an attempt is made to pull off a gear, collar, or other part which is screwed on, but which the operator assumes is keyed or pinned, the part will probably be spoiled before the mistake is discovered, entailing extra expense and delay. Many times a gear is such a close fit on a shaft that it has to be heated to free it, even after all other fastenings have been removed. In a case of this sort, all the repair man can do is to be sure he is right, and then keep at it until it comes off. As soon as the refractory part has been started, a little lubricant should be squirted in, and the piece driven back to its former position. It will then start off a second time much easier and go farther. In similar ways, lubricant is as useful in disassembling as it is in running the car.

REPAIRS

Overhauling the Engine. By far the most important part of the car is the engine, and this should, therefore, receive the greater portion of the time and attention during any repair or overhaul work, going so far as to take it out of the chassis if the trouble is at all serious. For this purpose, all ignition wires and carbureter and magneto operating rods are detached. Next the various manifolds are removed, the water system is drained, and all hose connections are broken. Usually it is necessary also to take the radiator

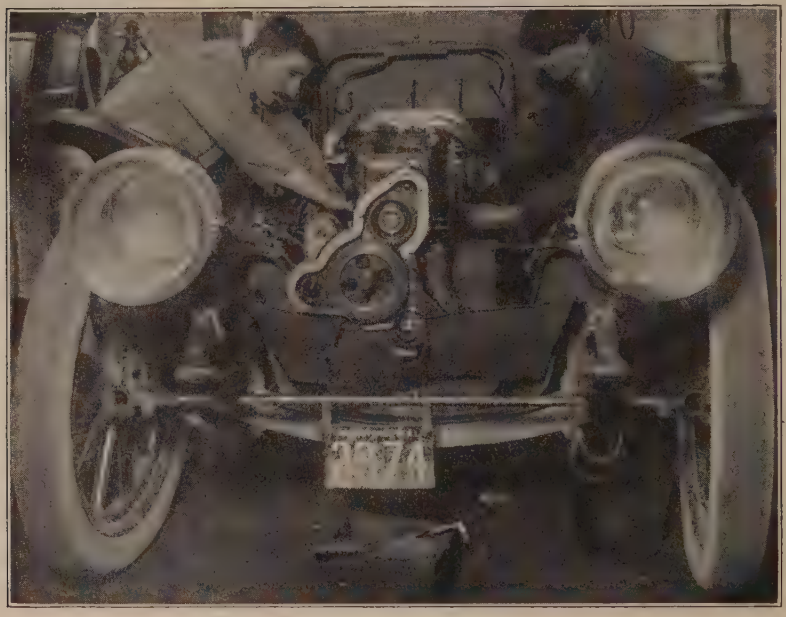


Fig. 39. Dismounting the Engine for Repair

off, in which condition the appearance of the vehicle and the work is very much like that presented in Fig. 39, which shows two men busily engaged in loosening up certain parts of the engine preparatory to taking it out.

When all accessories have been removed or loosened up, the holding bolts are taken out, and the clutch disconnected, leaving the motor free to be swung out by means of a small crane or hoist. In some cases, the work can be completed without disturbing the base of the motor, as in Fig. 40, which shows a big car partly

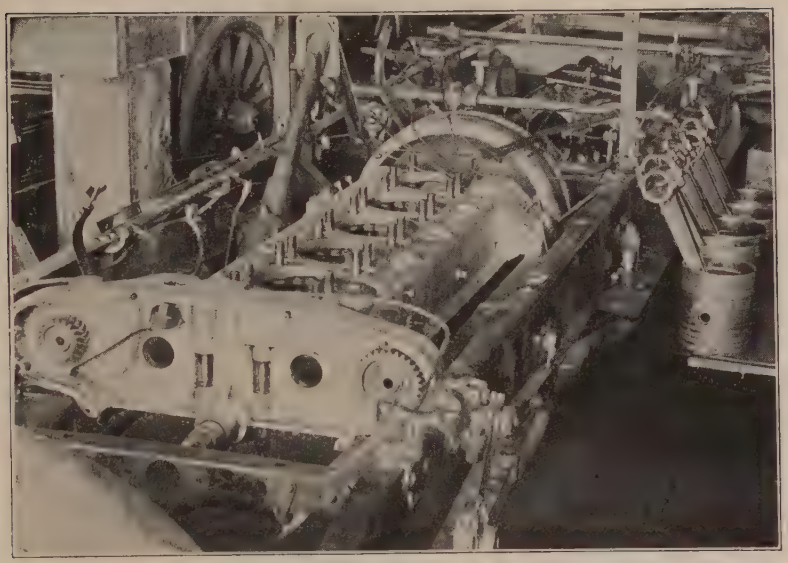


Fig. 40. Engine Dismounted Showing Cylinders Removed

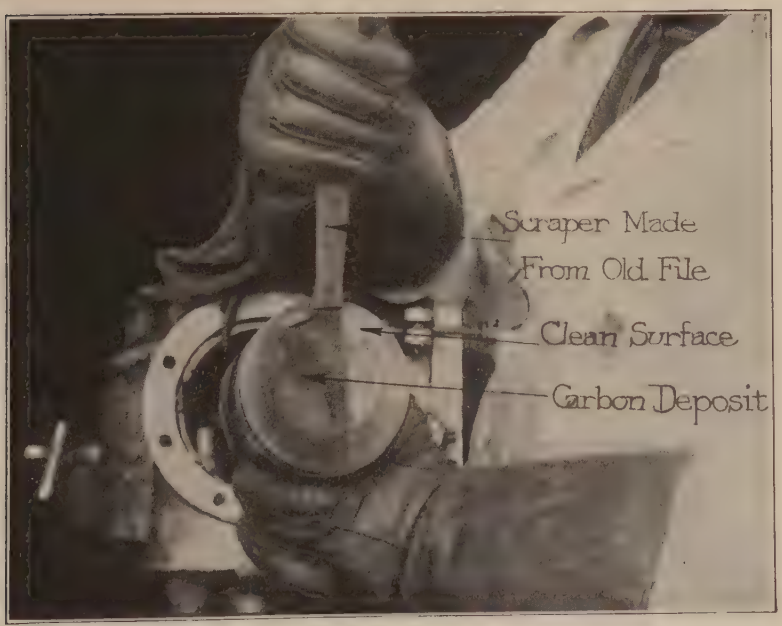


Fig. 41. Removing Carbon with File

disassembled for repairs, the radiator and cylinders being off at this stage. The trouble here was found within the cylinders, hence, as soon as they had been removed, the balance of the six-cylinder motor and its chassis could remain undisturbed.

Removal of Carbon. One of the first things the owners will meet is the removal of carbon. When the offending member has been brought out so it can be handled, the removal of the carbon can be accomplished in a few minutes. As shown in Fig. 41, the scraper is made from an old file, flattened out at the end, and ground down so as to present one sharp edge. Every owner should accumulate from five to a dozen shapes and sizes of scrapers for various work, including a flexible one with which to reach into corners, etc. A flat piston head like that shown can be scraped off with any knife or chisel, but a special tool is better. The carbon is brittle and comes off readily, after which the surface should be filed or rubbed over with emery and oil to make it smooth, in order to delay the formation of a second coat.

This is true of carbon in other places, but usually it is impossible to smooth the surface, in which case the process must stop when the part is scraped clean.

Removal and Replacement of Pistons. Speaking of pistons, there are several things that the beginner should learn about their removal and replacement. While it is not a difficult matter to pull a piston out of a cylinder, when both have been previously lubricated, and all proper precautions taken to loosen connecting parts, there are a few important things to remember.

The piston should be drawn out as nearly parallel to the axis of the cylinder as is possible, accompanied by a twisting motion not unlike taking out a screw, in case it sticks a little. If the piston sticks badly, pour in a little kerosene, which is thinner than cylinder oil, and work the piston in and out so as to distribute the kerosene between the two surfaces. When this member has been removed, the presence of carbon on the top will indicate the necessity of scraping the rings and the spaces below them.

To get at the spaces, the rings must be removed, and as they are of cast iron and very brittle, this is a delicate task. Two methods of accomplishing this are illustrated in Fig. 42. If the owner has a pair of ring-expanding pliers, the rings can easily be

expanded enough to lift them over the edge as shown in (a). As very few owners possess this useful tool, however, a more common way is shown in (b). Secure a number of thin, flat steels about $\frac{1}{2}$ inch wide and $\frac{1}{16}$ inch thick, corset steels, flat springs, or hack saw blades may be used, although the latter require more care on account of the teeth along one edge. The length of these steels should be such as to reach from about an inch below the last ring to the top. Lift out one side of the ring with a small pointed tool and slip one

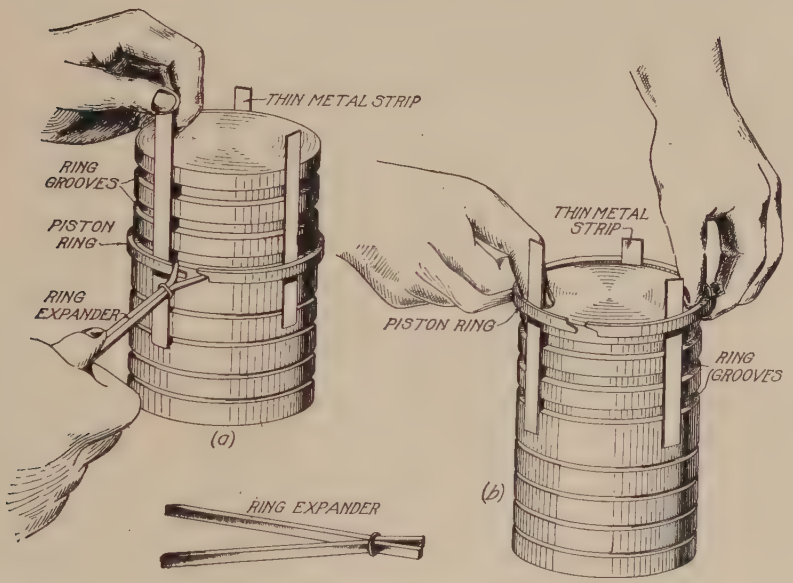


Fig. 42. Method of Removing Piston Rings

of the steels between the ring and the piston; then move around about $\frac{1}{3}$ of the way and insert another, taking care to hold the first in place; repeat the operation with a third steel. When these are in place the steels will hold the ring out from the piston enough so it may be slid over the "lands" between the grooves, and along the steels to the top.

Always begin at the bottom, working up, when removing rings, and just the opposite, from the top down, when replacing them. After one is mastered, the removal of the others is a simple matter of repetition. The grooves can now be scraped free of the offending

carbon, a process which is but an inversion of the previous method, after which it will be necessary to replace the rings.

Replacing the piston in the cylinder is a more difficult operation. There are two ways of doing this, viz, by a special form of ring closer, and by hand, using a string. The former is a shaped device which is clamped around the ring and squeezed together with pliers, using one hand, while with the other hand the ring is guided into the groove. The second and more usual method is illustrated in Fig. 43,

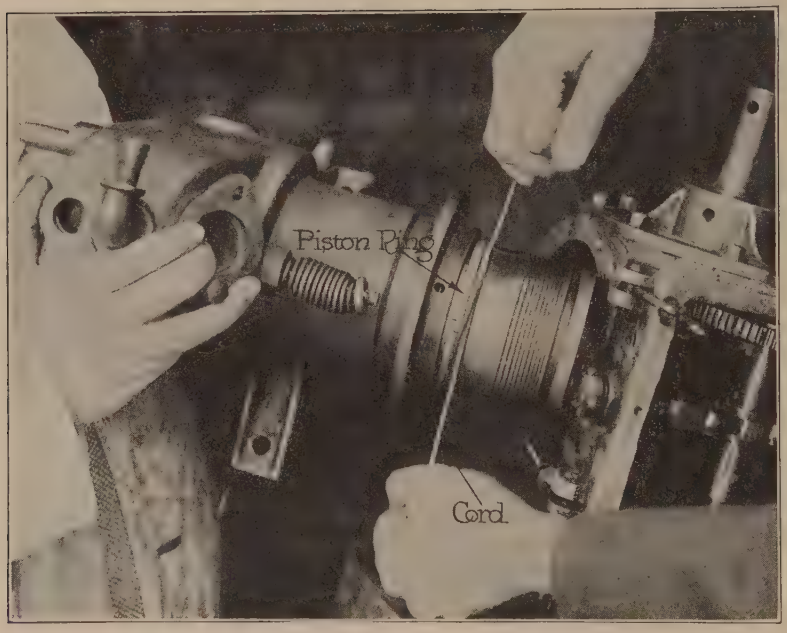


Fig. 43. Method of Re-Assembling Piston Mechanism

and requires two men, unless the cylinder is of such a shape that it can be clamped in a vise. As the picture brings out, one man holds the cylinder while the other forces the piston carrying the rings into place. The piston is shoved in until the expanded top ring prevents further movement, when a heavy cord is placed around the spring, and the ends are crossed, thus closing up the ring and allowing the piston to slide in as far as the next ring. The operation is repeated successively for the other rings. This is a very simple method and requires only patience.

Bearings. Bearings of the two-piece or split type give the amateur repair man fully as much trouble as anything, in fact, the crank shaft bearings should not be tackled until considerable repair experience has been had. In general, wear on the bearings is due to one of two causes, either a soft metal which has caused vertical wear on the inside or outside of the lower half of the bushing, or a vibrating shaft which has worn an oval hole somewhere in the length of the shaft, as at the inner or outer end.

In the former case, the height of the worn half must be reduced, which is usually done by taking off from the upper face as much metal as is needed. When this has been done either by filing or by rubbing across emery cloth wet with oil, the two halves of the bushing will approach so close together that the hole will be smaller than the shaft. This will necessitate scraping out or reboring according to the amount which has been taken off. In the case of very small amounts, this wear can be taken up by removing shims, which are small filling strips of sheet brass which hold the halves of the bushing apart and thus make the central hole larger. The sizes of these shims vary from .003 to .008 inch, several of each being used. By selecting those which are to be removed, or taking out one size and replacing with another, any variation in diameter from .001 to .025 can be remedied. Of course this method changes the hole from a round to a slightly oval hole, but this may be remedied by a very small amount of scraping.

When the second form of wear is found, that is, when the bushing is worn oval by a wobbling shaft end, the only remedy is bringing the bearing halves together as before and reboring. It may be that this operation robs the bearing plates of so much metal that they will not fit the holes in the case; or possibly the wear may have communicated itself to the case, so that the hole there is out of true. If this be slight, refilling the cases with babbitt metal or building-up may be resorted to, but if the wear is considerable, a new set of bearings is the only remedy. In building up the bearing, strips of soft metal are placed in the worn spots, after cutting or filing them to fit as closely as possible, and the bearing driven down upon them as firmly as possible. In this way, it is often possible to build up a worn crank case to answer for many thousand more miles running.

Valves. Valves present another fertile source of trouble. These troubles may be of three varieties: Worn or pitted seats, worn or pitted valves, and bent or worn stems or stem guides. In the latter case additional air is admitted, allowing the mixture to become more dilute than the operator realizes until the engine begins to miss fire. If the stem be at fault, this may be turned down to a smaller size, perfectly round, and a new bushing with a hole of the new size fitted into place.

In case the trouble lies with the bushing, those of the one-piece type must be replaced if there is much wear; but if the wear is slight, a clever repair man can pein* the edges and considerable metal adjacent to them, so that a much smaller hole is formed, after which reboring to a tighter fit is in order.

When either the valve stem or seat has become worn or pitted, it must be reground. This is accomplished as follows: Secure a small amount of flour of emery, the finer the better, and mix this into a thin paste using cylinder oil, or graphite, or both. Loosen the valve, disconnect all attachments, remove the valve cap above, and free the valve in a vertical direction. Now lift it out, place upon the seat a daub of the emery paste and replace the valve. With a large screw-driver press the valve firmly in place, at the same time rotating it about one fourth of a turn to the right and then the same amount to the left.

While doing this, the other hand should be held below the valve stem with one finger just touching it. After moving back and forth about eight or ten times, lift the valve off of its seat with the finger, turn it through a quarter turn, and drop it back into place. Then repeat the grinding, until the whole circle has been covered several times. Then remove the valve and clean off both moving member and seat with gasoline. With a slight touch of Prussian blue, mark the seat on the valve, replace, and twirl around several times so as to distribute the color. Remove the valve without touching the seat portion on it or in the cylinder, and examine both. If the grinding process has been complete and accurate, the color will have been distributed in a continuous band of equal width all around the surface. If not continuous, or not of equal width all around, the

*Force the metal nearer the center of the hole by means of a prick punch or by a pointed hammer.

task is but partially completed and must be continued until the full streak results. On the first attempt at this rather delicate piece of work, it is well to call in an expert repair man to examine and pass upon the job.

Clutches. Clutches offer many chances for trouble, the wear of leather facings and the loss of power attendant upon this, slippery or dry leather or weak springs being the principal factors. Let us consider these in the reverse order. Weak springs may be cured usually by screwing up some adjusting nut or bolt provided for the purpose. Slippery leather may also be corrected by washing first with gasoline and then with water, finally roughing the surface with a coarse rasp and replacing only after the leather is thoroughly dry. Dry leather is fixed by soaking in water, or if possible in some oil or preparation which will soften it, like neatsfoot oil; the leather should be replaced while still moist, and copious lubrication will keep it soft.

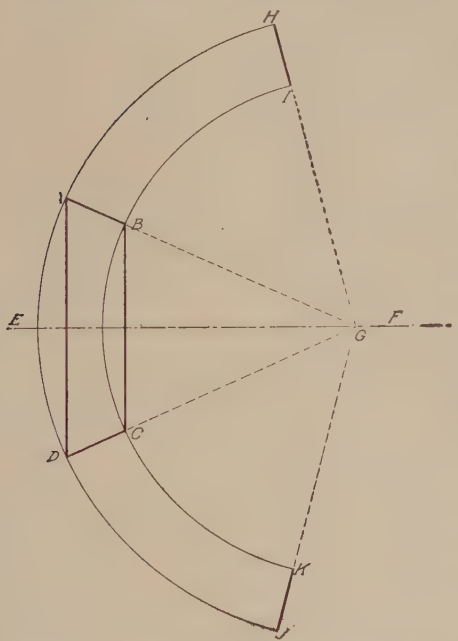


Fig. 44. Diagram Showing How to Cut Clutch Leathers

The greatest problem in replacing a worn, charred, or otherwise defective leather lies in getting the right layout for the form of the new leather the first time. It must be remembered that the surface is a portion of a cone and, therefore, its development is not easy. It is attacked in this manner: Prepare the cone by removing the old leather and all rivets, cleaning out the rivet holes and providing new rivets. Measure the cone, taking the diameters at both the large and small ends, and the width. Take a large sheet of paper, and lay off upon it a figure similar to *ABCD* in Fig. 44, drawn to exact scale and having for its dimensions the three measurements just obtained, viz, the large and small diameters and width of the cone. This

figure represents the projection of the cone in a flat plane. Bisect the line *AD* and draw the center line *EF* at right angles to *AD*. Prolong the two tapered lines *AB* and *DC* until they meet the center line as at *G*.

This point *G* represents the apex of the cone if it were complete, and hence any circular arc drawn from this point as a center, and with the correct radius, will be a correct projection of the development of that portion of the conical surface. With *GA* and *GB* as radii, draw the two circular arcs *HADJ* and *IBCK*, also drawing

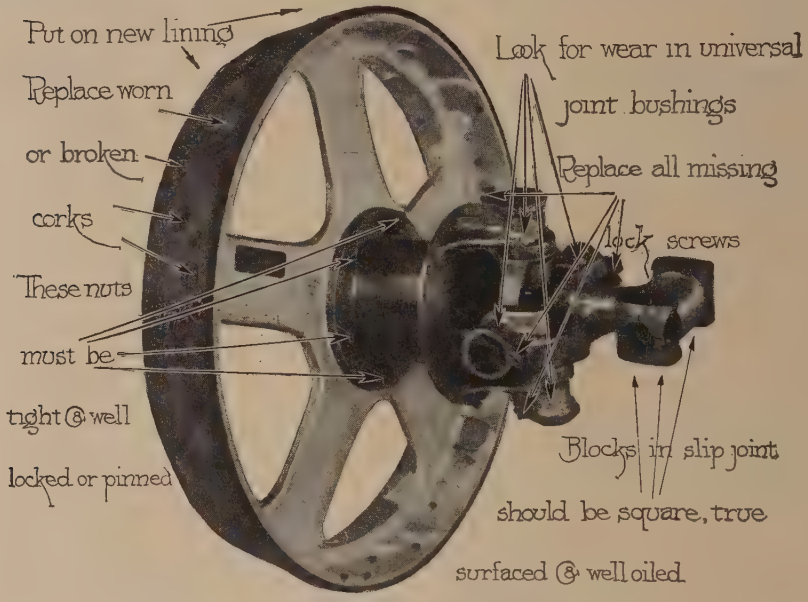
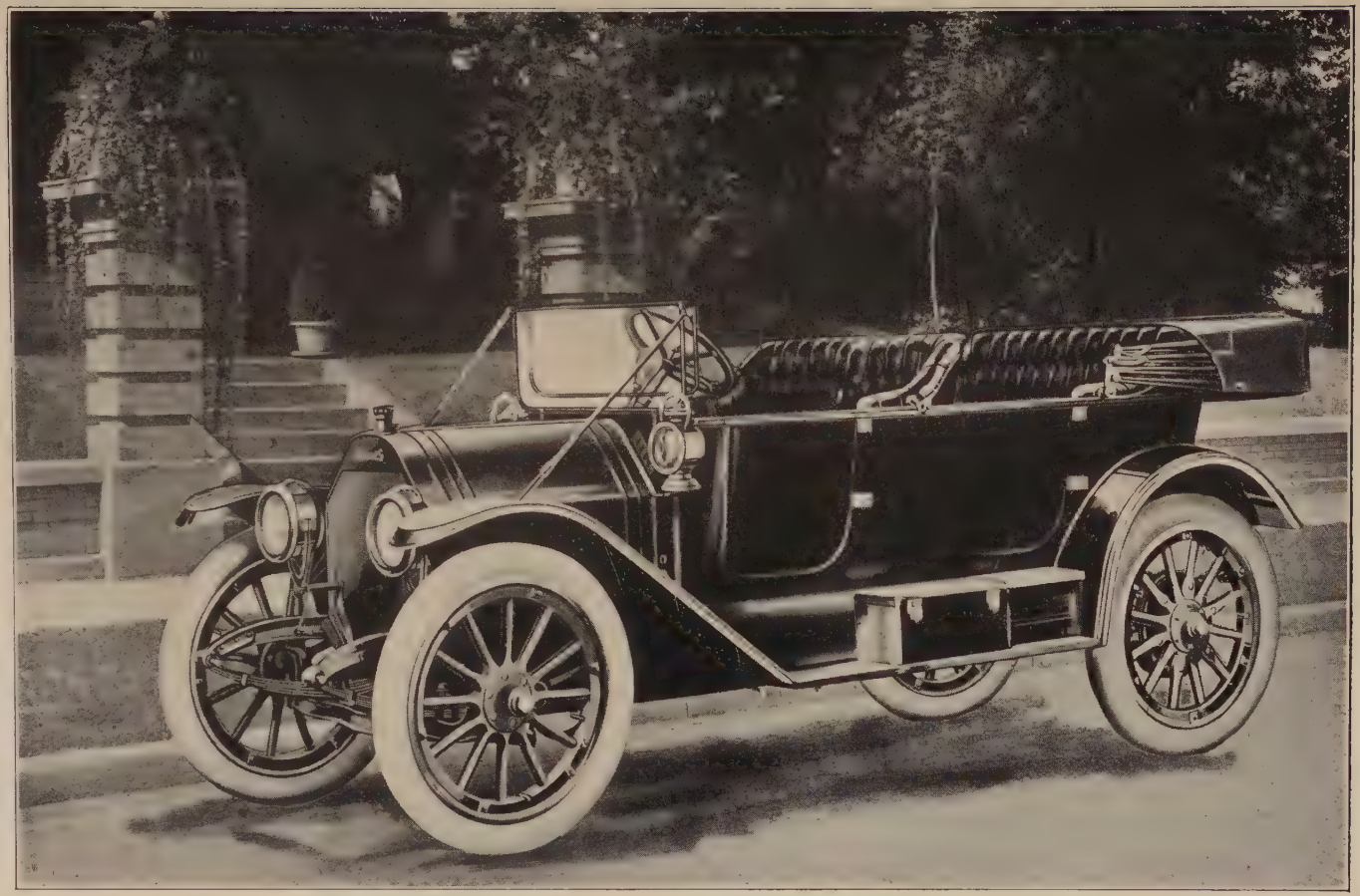


Fig. 45. Clutch Troubles Illustrated

the radial lines *HI* and *JK* to pass through *G*. The enclosed figure *HIBCKJDAH* may then be cut out and used as a pattern from which to cut out clutch leathers. If the distances *AH* and *DJ* be made approximately equal to or slightly more than *AD*, the pattern will a little more than encircle the cone clutch.

After the leather has been cut out, it should be prepared by soaking in water or oil, according as its surface is fairly soft or rather harsh. In either case, it must be well soaked, so as to stretch easily. In putting it on the cone, one end is cut to a diagonal, laid down on the cone, and riveted in place. Next, the leather is drawn down



HAYNES MODEL 21 CLOSE-COUPLE TOURING CAR

The Haynes Automobile Company, Kokomo, Indiana

tightly past the next pair of rivet holes which are then driven into place. This is continued until the strip is secured. The leather is now wetted again, for, if allowed to dry off immediately, the shrinking action will break it out at most of the rivet holes and render it useless. By drying out gradually, a taut condition may be arrived at without this danger.

In Fig. 45, several other common clutch troubles and their remedies are suggested, the parts shown in the illustration, however, being in excellent condition, in fact new.

Transmission. Passing along to the transmission, Fig. 46 shows a plan of a gearbox in which the disk clutch is also housed, the various possibilities for trouble or suggestions for its avoidance

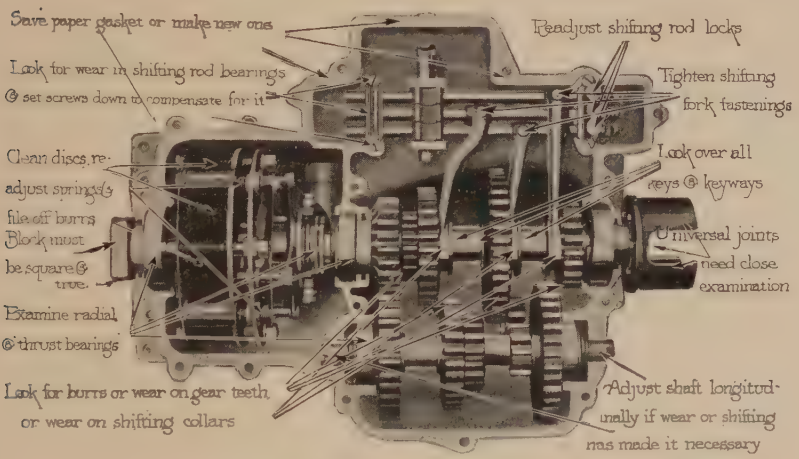

Save paper gasket or make new one
Look for wear in shifting rod bearings & set screws down to compensate for it
Clean discs re-adjust springs & file off burrs
Block must be square & true.
Examine radial & thrust bearings
Look for burrs or wear on gear teeth or wear on shifting collars
Readjust shifting rod locks
Tighten shifting fork fastenings
Look over all keys & keyways
Universal joints need close examination
Adjust shaft longitudinally if wear or shifting has made it necessary

Fig. 46. Transmission Troubles Illustrated

being marked. In this type of clutch, the greatest possibilities lie in the burring of the disks or a lack of spring adjustment. If the former, the burrs can be filed off with a fine file, while the latter trouble is avoided by merely tightening the spring-adjusting springs, trying the effect of this and tightening again, until the correct and satisfactory position is obtained.

In transmissions, the possibilities include the following: Burred teeth; gears worn where they slide along the shafts on keys or in keyways; looseness in the main bearings; and play in shifter rods or their locks. Where the gears clash, one against the other in shifting,

unless the faces of each have been chamfered and rounded off nicely and are well hardened at these points, there is liable to be set up a cutting action which gradually wears a high burr in one or both. When the two are in mesh, the burrs are on opposite sides and contacting with the meshing gear. This will make a continuous noise. Its remedy is the removal of the gear, the filing off smooth of all raised portions, the filing or grinding out of all low spots cut into the teeth, and subsequent hardening to make repetition impossible.

If the gears have worn at the center hole where they slide on the shaft, either in the round hole or at the keyway, this must be fixed at once. In the former instance, the gear can be bushed, and the bushing bored out to fit the shaft, while in the latter, a slightly larger key may be fitted in the shaft and the keyway may be recut to accommodate this. Where the keys have been let into the shaft, they may have worn in one spot or at the ends. If the wear is all in the key, this can be replaced with another of the same size, but made slightly harder in the process.

If the main bearings are of the roller type, the wear may be taken up by readjusting the position of the roller on the cone, but if they are of ball or plain bushing form, replacement is almost the only remedy, unless it happens that in the case of a plain bush, this is split, so that something may be filed off of the two contacting sides, and the holes trued out to this new size. In that case, the advice previously given under the subject of plain engine bearings will be applicable.

Play in the shifting rods may be traced to one of two things: Looseness at the connection of two rods, or of a rod and a lever; or looseness in the bearings. The former inevitably requires a new and slightly larger pin, driven into the place occupied by the previous member. Loose bushings will mean new ones if the trouble is serious, for this form is almost always of the solid and, thus, non-adjustable type. In many cases where wear occurs on a solid plain bearing used on the end of a plain round shaft, if peining can not be resorted to, as suggested previously, the shaft may be turned down a very little bit, say $\frac{1}{16}$ inch, the bushing turned out an equal amount, and a thin sleeve bushing made of this thickness all around, and forced into the previous member. This saves reboring the case, which is an expensive and difficult job, while both the shaft and bushing jobs are simple ones.

If a serious defect develops in the case, this may be cleaned out and welded. This is not a job for the amateur, but the closing of a simple crack, no matter how long, would be an easy proposition for the owner of a welding outfit; moreover, it would be a very short, quick job. Autogenous welding should always be resorted to as soon as a crack or break is detected, for this may save the expense and delay of a whole new case, the former costing, say, 50 cents to $1 while the other easily may amount to $50.

Driving Shaft. From the gearbox to the rear axle the power, in the majority of cases, is transmitted by a long shaft. This may have either one or two universal joints in its length. The purpose of these is twofold: to permit the rise and fall of the rear axle relative to the rest of the car, and to allow similar side sway in which the whole rear construction participates. These joints are covered usually with leather casings which are packed with grease. These keep out the dirt and, consequently, lessen the wear, and also lubricate the moving parts of the joints. A secondary function of the casings is to render these joints noiseless. If a car is not equipped with them, it is advisable for the owner to purchase them.

The shape of these casings when opened out flat would be not unlike that of two bottles with their flat bottoms set together, that is, narrow at the top and bottom and wider at the middle. All along both edges are eyelets for the lacing. The enlarged center fits around the joint, while the small ends encircle the respective shafts. To apply the casing, one end is placed around the shaft on one side of the joint and the lace started; then the lacing proceeds, gradually drawing the ends together and around the joint. When this has been completed and before the last end is closed, the whole is shoved back along the first shaft a little way and the center portion half filled with a heavy grade of transmission grease. This done, the glove is pulled back into place and the work of lacing completed around the second shaft. Both ends should be laced as tightly as possible while the middle part should be loose.

Rear Axle. Rear axles do such hard work, and must stand up under such a large portion of the load carried in the machine, that they offer many chances for wear, adjustment, or replacement.

Brakes. First and foremost are the brakes, which now are usually placed side by side within the drum attached to the wheel,

as shown in Fig. 47. This shows a semi-floating form of rear axle with the two sets of brakes and operating shaft and levers. A number of suggestions are placed upon this, among which will be noted this: "Renew worn brake lining and broken or loose rivets."

When a brake lining is worn, the proceeding is much the same as with a clutch leather previously described, with the exception that, whereas the latter must have a curved shape, the former can be perfectly straight and flat. This simplifies the cutting, but as most brake linings are made of special, heatproof, asbestos composition which is made in standard widths to fit all brakes, the cuttings of leather brake bands is not often necessary.

Truss Rods. Truss rods hold the wheels in their correct vertical relation to the road surface and to one another. If through wear

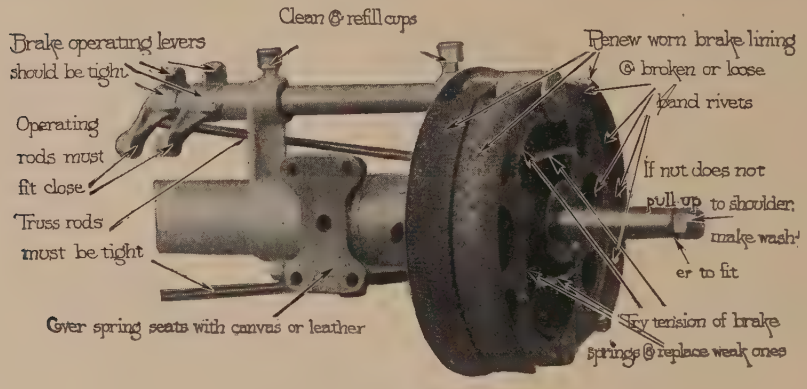

Clean & refill cups
Brake operating levers should be tight
Operating rods must fit close
Truss rods must be tight
Renew worn brake lining & broken or loose band rivets
If nut does not pull up to shoulder, make washer to fit
Cover spring seats with canvas or leather
Try tension of brake springs & replace weak ones

Fig. 47. Brake Troubles Illustrated

or excessive loading, the axle sags so that the wheels tip in at the top, presenting a knock-kneed appearance, the truss rods must be tightened up so as to remedy this. Usually they are made with a turnbuckle set near one end, a locknut on each side preventing movement. The turnbuckle is threaded internally with a right-hand thread on one end and a left-hand on the other, so that a movement of the turnbuckle draws the two ends in toward one another, shortens the length of the rod, and thus pulls the lower parts of the wheels toward one another, correcting the tipping at the top.

To adjust for this trouble, loosen both locknuts, remembering that one is right-handed and the other left. Then, with the wheels

jacked clear of the ground, tighten the turnbuckle. A long square should be procured or made so that the wheel inclinations may be measured before and after. Placing the square on the ground or floor, which should be selected so as to be perfectly level, the turnbuckle should be moved until the tops appear to lean outward about one half inch—some makers advise more.

Springs. If either rear or front springs squeak, the car should be jacked up above them, and the leaves separated with a screwdriver or other flat tool. Grease or a mixture of grease and graphite can then be inserted between the ends of each pair of plates. This not only eliminates the noise, but also makes the springs work better and makes the car ride better.

Rear Construction. In disassembling the rear construction for purposes of adjustment or repair, the beginner should be very careful to mark all parts. Those parts which have been running together for many thousand miles act better and with less friction than would those which have never run together, despite the fact that the duplicate parts are supposed to be alike and interchangeable. It is therefore suggested that separate boxes be provided for the parts taken from the two ends or sides.

Method of Disassembling. The method of procedure for this is about as follows: Jack up the axle, replacing the jack with small horses or blocks of wood if possible. Then take off the hub caps, free the wheels, and take them off. Disconnect the brake operating rods and levers and remove them from the car, marking them carefully. Spread the brake shoes apart, loosen the springs at one side, and take out the springs, and then the brake shoes themselves. Remove the brake operating shaft with the cams; then disconnect the spring bolts and jack up the chassis, using the spring for a support. Disconnect all torsion or radius rods, and take off the grease boot around the universal joint in the driving shaft. Open this joint, and disconnect the shaft. Take this off, and if the spring bolts have been removed, the rear axle will be free. Pull this out from under the chassis, and if desired, further disassembling may be done more easily with the member clamped in a vise or laid on a bench.

Assembling. In assembling, almost the reverse of this process is followed, the parts going together in the opposite manner from that in which they were taken down.

Difficult Jobs Novice Should Avoid. The following jobs, sometimes lightly spoken of, are not considered advisable for the novice, or even a motorist with less than a year's experience, to tackle: Removing rear axle as just described; adjusting differential bevel gears; scraping main or connecting-rod bearings in the engine or principal bearings in a transmission; replacement of main, connecting-rod, or piston-pin bushings in engine, or principal bearings in the transmission; alterations in the clutch aside from new facing and spring tension adjustment; any internal work upon the magneto; any alteration in the timing; any change in the lubricating system; changes in valves aside from simple adjustment; alterations in the flywheel to increase or decrease its weight; any interference with the parts concerned with a correct running balance (connecting rods, crank shaft, flywheel, pistons, and rings); any alteration in the car operating system; changes in the braking, aside from spring tension; or other items of large importance.

Generally speaking, if the car operates properly, quietly, and efficiently, there is no real reason for the beginner with but a few months' experience attempting to improve upon the manufacturer's design and construction which are the results of years of study, the analysis of the experience of thousands of car owners of that and other makes, and in part a compromise between what the maker really would like to build and what the buying public demands and will have.

Tires. Before concluding these remarks on the general subject of small overhaul and repair work, it will be well to say something on the subject of tires. These are at the same time the most delicate, the most misunderstood, and the hardest working parts of a car. They are delicate because the materials comprising them are soft, pliable, and very easily damaged, as compared with the various selected metals entering into a car's makeup. They are misunderstood for various reasons, and in many different ways; composition, utility of and necessity for the various components, proper and improper methods of use, correct and incorrect inflation pressures, troubles and their remedies, and many other things, all come under this category.

Broadly speaking, all tires consist of two parts, the tube and the shoe or casing. The former is a plain round ring of circular cross section, made of pure rubber, containing an air valve, and is intended

only to hold the air. The shoe or casing, on the other hand, provides the wearing surface, protects the air container within from all road and other injuries, and constitutes or incorporates the method of fastening itself to the wheel. In its construction are included the fabric—preferably cotton—some pure rubber, and much rubber composition, the whole baked into a complete unit by heat and in the presence of sulphur, which acts somewhat as a flux for rubber.

Considering a typical tire, there enters into its makeup, starting from the inside, six or seven strips of frictioned fabric—that is, with thin sheets of pure gum rubber rolled into intimate contact with each side of the cotton, making it really a rubber-coated material. Next, there is the so-called padding which is more or less pure rubber, has a maximum thickness at the center of the tread, and tapers off to nothing at the sides, but usually carrying down to the beading. Above this, there is placed a breaker strip, consisting of two or three layers of frictioned fabric impregnated in a rubber composition. This, too, is thickest at the center and tapers off to the sides, but ends at the edge of the tread. Finally, there is the surface covering, called by rubber men *the tread;* this contains very little pure rubber, being thickest at the center and extending with gradually decreased thickness almost down to the bead.

The last two of this series of layers constitute the real wearing surface of the tire, and when the surface is so worn that the breaker strip may be seen, it is time to have the tire retreaded. When the wear has gone through this, if the padding be fairly complete, retreading will still save the tire, but if wear has gone clear down through that so as to expose the fabric, the shoe must be run to a finish and then discarded.

An ordinary puncture simply penetrates the outer casing, and punctures the tube. When the latter has been patched, the whole tire is apparently as good as new. In reality, it is far from that for the patch on the tube will never be as strong as the original, while the hole through the shoe may or may not be the cause of a subsesequent blow-out or other severe trouble. If the rubber composition is at all torn, this should be taken to a repair man for a small insert of patching rubber, and vulcanization. This makes the shoe practically as good as new, for the vulcanizing operation incorporates the small patch into the tire as firmly as any other part of it.

If not vulcanized, a small pebble may lodge in this little hole, and through the pressure of the car upon it and road shocks and blows, may be driven gradually inward, opening up the hole as it goes, until other and larger stones are picked up, driven in, and the work of destruction continued. This goes on, if the owner does not notice and fix it, until the material above the air tube, pumped up to perhaps 75 or 80 pounds pressure per square inch, becomes too thin and weak to support it longer, when a small explosion takes place, the air bursting through the envelope. This is technically known as a blow-out, and if severe or far reaching, may put the valuable casing beyond the reach of repairs.

Not all blow-outs are caused in this way, many occurring on the side of the tire where a fault develops, which is enlarged by a blow or cut, until the material can stand the internal pressure no longer. When the car is run continuously in car tracks, or in the deep ruts of a country road, the thin sides of the tire chafe off very rapidly, more so than the tread under similar circumstances, for the rubber on the side is purer and, being softer, cuts more easily.

Whenever the surface of a tire, comparatively new and thus worth looking after, is injured and a portion of the material accidentally removed, it is well to repair this and vulcanize it one's self, or else take it to the tire repair man. These few remarks, all including some mention of the ever useful vulcanizer and its utility, but lead up to the statement that every motorist should own one of the accessories and utilize it upon every possible occasion.

While neither this treatment nor anything else will make an old tire new, it will help greatly in keeping a new tire new and in the best of condition, it will keep the tire repair bills down to a minimum, and it will decrease greatly the tire cost per mile, and in these and other ways contribute much to the pleasure of motoring.

Washing tires often is a good practice, for water does them no harm, while all road and car oils and greases will be cleaned off, nearly all of these being injurious. Frequent washing will also serve to call the owner's attention to minor defects while they are still small enough to be easily repaired and are thus prevented from spreading. When not in use, tires should be wrapped, so as to be covered from light, and put away in a dry room in which the temperature is fairly constant the year around. They will not stand

much sunlight, nor many alterations of temperature. Cold hardens the tires and causes rubber to crack. Heat has a somewhat similar effect and also draws out its life and spring.

In general, of all things to be cared for and repaired promptly, no one thing is of more importance than the tires. If this rule be kept in mind, better satisfaction in the use of the car will result. So, too, with other repair work, if tools and appliances are made available, and repairs made as soon as needed, the car will be better understood and give more satisfaction than if the opposite course be pursued. A few short months' use of a car will do more to emphasize this than any amount of talk. Keep your car in good condition and you will reap the benefits of the little work you do upon it.

MORS CAR
With Collomb (A World's Record Holder) Driving.

AUTOMOBILE DRIVING

First get your car, then learn to use it. This homely phrase based on another one equally homely and of daily use, sums up in a few words the matter of learning to drive a car. After the car has been duly purchased, the glib salesman will show one in about four minutes how to drive. Yet after all this assistance, it will take almost any man of fair intelligence a whole week or more to learn to run the car alone and with confidence, while he will continue to learn additional points as long as he continues to drive. Although the gasoline engine, in combination with the other mechanical parts of the ordinary touring car, is not so very complex when tackled in a common-sense manner, there are so many things which enter into the whole makeup and which may vary, either singly or in combination with others, that the combinations are practically infinite.

STOPPING THE CAR

Of premier importance is starting, and the proper way to go about it. But even before this is done, the beginner should learn to *stop* the car, for accidents often happen from inability to stop; never from inability to start. So, the first thing on the novice's program should be the matter of stopping.

Closing the Throttle. Without a doubt, the surest way to stop the car, one that is always effective, and by all odds, the first one for a beginner to learn is that of shutting off the *throttle.* This he must learn at once and before he learns anything else; it should be so thoroughly grounded and fixed in his mind that no matter what sort of a discomfiting situation he finds himself in, he will always think to shut off the throttle. This is effective, in that with the throttle closed, no gas can reach the engine, which, therefore, cannot run. If no gas be supplied and the engine cannot run, its own internal resistance, to be explained more in detail later, will stop the car very quickly, though not immediately. Other methods will stop the car

more quickly, but the novice might release them accidentally before the source of trouble was removed, making the situation as bad as, if not worse than, before. With the throttle closed, the engine stops and with it, of course, the car.

Fig. 1 shows how this is accomplished. Nearly every car has the spark control and the throttle placed upon the steering wheel, so as to be convenient. Practice varies whether the spark is placed above or below the throttle, but in any case, it is an easy matter to ascertain. This is done by lifting the *hood*, or *bonnet* as it is variously called, so as to expose the mechanism. Then any movement of a lever on the hand wheel moves either a part of the ignition apparatus or some portion of the carbureter. If the latter, the lever moved is then the throttle lever.

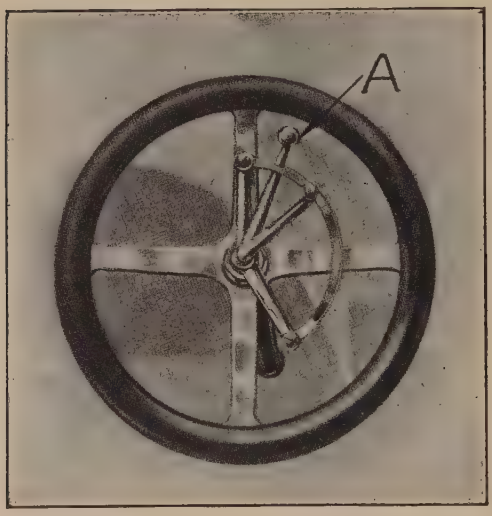


Fig. 1. Typical Steering Wheel.

It is not necessary to remember which movement of the throttle turns the mixture on or off, since, if the car is running, it must of a necessity be turned on; and to stop, it is only necessary to move it as far as possible in the opposite direction. In Fig. 1, the longer and more easily operated lever, marked *A*, is the throttle lever, and is shown in the "off" position. In the "on," or open position, this is at the side, where it is more convenient to the hands, which should always grasp the wheel at two points directly across the rim of the wheel from one another, *i. e*, 180 degrees apart. The ordinary application of levers is such that in this position, the location of the spark and throttle levers will bring them down close to the right hand; in which location, they may be operated without removing the hand from the wheel, a slight movement of the thumb or one finger being sufficient. For the "off" position, on the contrary, it is necessary to remove the

hand from the wheel and reach for the levers, either to put them both in the "on" position or both on the "off" location.

When the danger or source of trouble is fully removed, it is the work of a second to get out and start the engine again. This method of stopping the car by shutting off the engine, the beginner must learn at once and remember for all time, although later on, with more skill in handling the car, and increased presence of mind, the other and superior methods will doubtless be used in preference. This one has the merit, for the beginner, of removing for a considerable length of time all possibility of future danger, and only recurring of the novice driver's own volition. That is, there can only be additional danger when the engine is deliberately started again.

Emergency Brakes. Other ways of stopping the car are numerous, as stated before, but to mention them in order of merit, the best is a combination of the method just mentioned with the application of the *emergency brakes*. The latter are placed on the car, as their name would indicate, for the express purpose of stopping the car in an emergency. Usually they consist of a pair of very large and powerful brakes fixed directly to the rear wheels and operated by the outer of the two hand levers. These hand levers may act forward or backward, *i. e.*, they may be applied by a pull or a push. The method to be used will depend upon the specific car in question, since the makers differ as to this and the system of operation has never been wholly standardized.

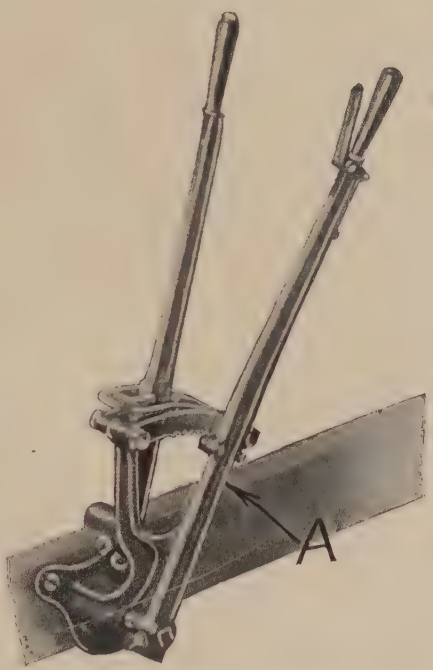


Fig. 2. Side Levers of Pope-Hartford Car.

Two figures are given to show this. Fig. 2 is that of a popular car on which the lever *pulls back* to apply the emergency brakes.

The right-hand lever, marked *A*, is for the brakes. This is retained in place by a ratchet which is discernible on the under side of the quadrant bars. In Fig. 3 is to be seen the controlling levers of another equally popular four-cylinder touring car, on which the emergency brake lever, marked *B*, *pushes forward* to apply the brakes.

Service Brakes. All modern cars are equipped with a secondary set of brakes, which are known as the *service brakes*, and are applied by means of a foot pedal. While this has not been standardized any more than the action or placing of the emergency brake levers, it happens that the majority of car builders utilize the right-foot pedal for this purpose. This operates a second set of brakes placed upon the rear wheels of a shaft-driven car, according to the latest practice, or upon the countershafts of a chain-driven car. It is sometimes a single, wide-faced brake placed upon the main shaft just back of the transmission as shown at *C*, Fig. 4. In any case, pressing the pedal *D*, Fig. 3 and Fig. 4, forward and down applies the secondary set of brakes. These being applied by means of a foot pedal while the emergency brakes are operated by means of a hand lever, makes it possible to apply both at once, with superior braking results. In the use of a *pull-back* emergency lever, it is possible to apply the foot brake first, and with the leverage upon this as a brace, apply the emergency brakes more forcibly.

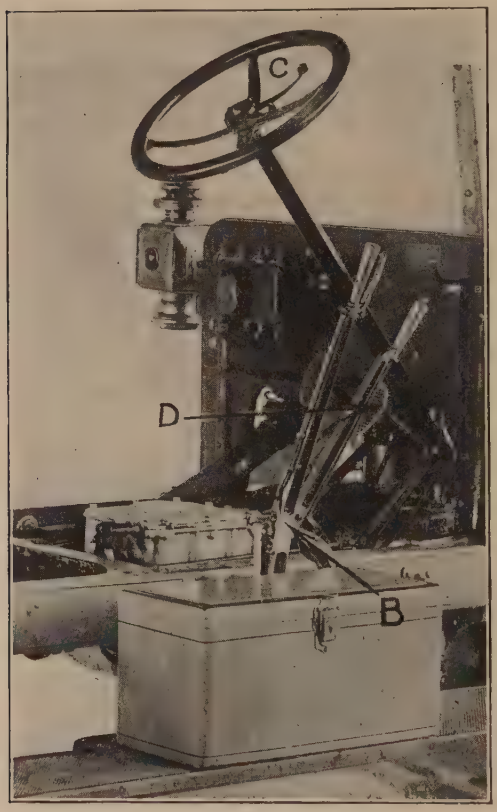


Fig. 3. Control Group of Mora Car.

It must be remembered in the use of both of these, that the operator is simply using his strength and the increased leverage which the arrangement gives him, against the force of the engine, and that other conditions being the same, when the foot pedal and

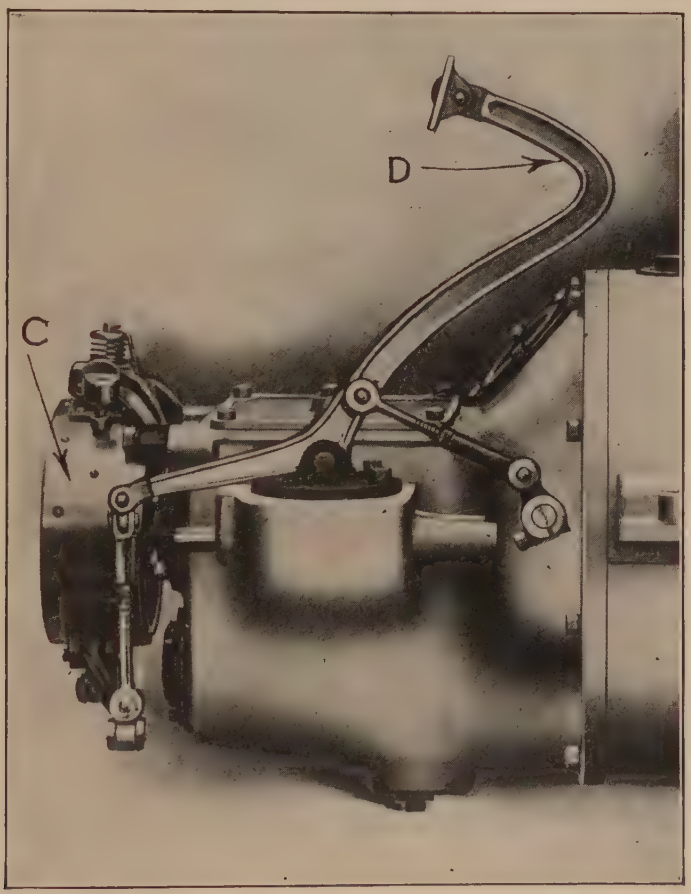


Fig. 4. Service Brake and Operating Pedal on the Chalmers.

hand lever are removed or released, the engine will go on propelling the car just as fast as before the brakes were applied.

Using the Engine as a Brake. A fourth method, and one which takes care of the case just mentioned, is that of throwing off the spark. This is brought about by means of the spark advance lever on the hand wheel previously spoken of, and shown at *C* in Fig. 3.

Throwing off the spark prevents the ignition of the charge just drawn into the cylinder, or any succeeding charges, until the spark is again thrown on. This causes the engine to draw in gas, compress it, and eject it without receiving a power impulse. All this takes power; since none is supplied, the forward energy of the moving car is consumed in turning the engine over; this rapidly subtracts from the momentum of the car, and in that way soon brings it to rest. In the language of the automobile driver, this is the act of *using the engine as a brake.* Despite its effectiveness, the practice is to be deprecated because it is at the same time wasteful of fuel and is said to be hard on the engine, which, after all, is the vital, beating heart of any car, and should have corresponding care.

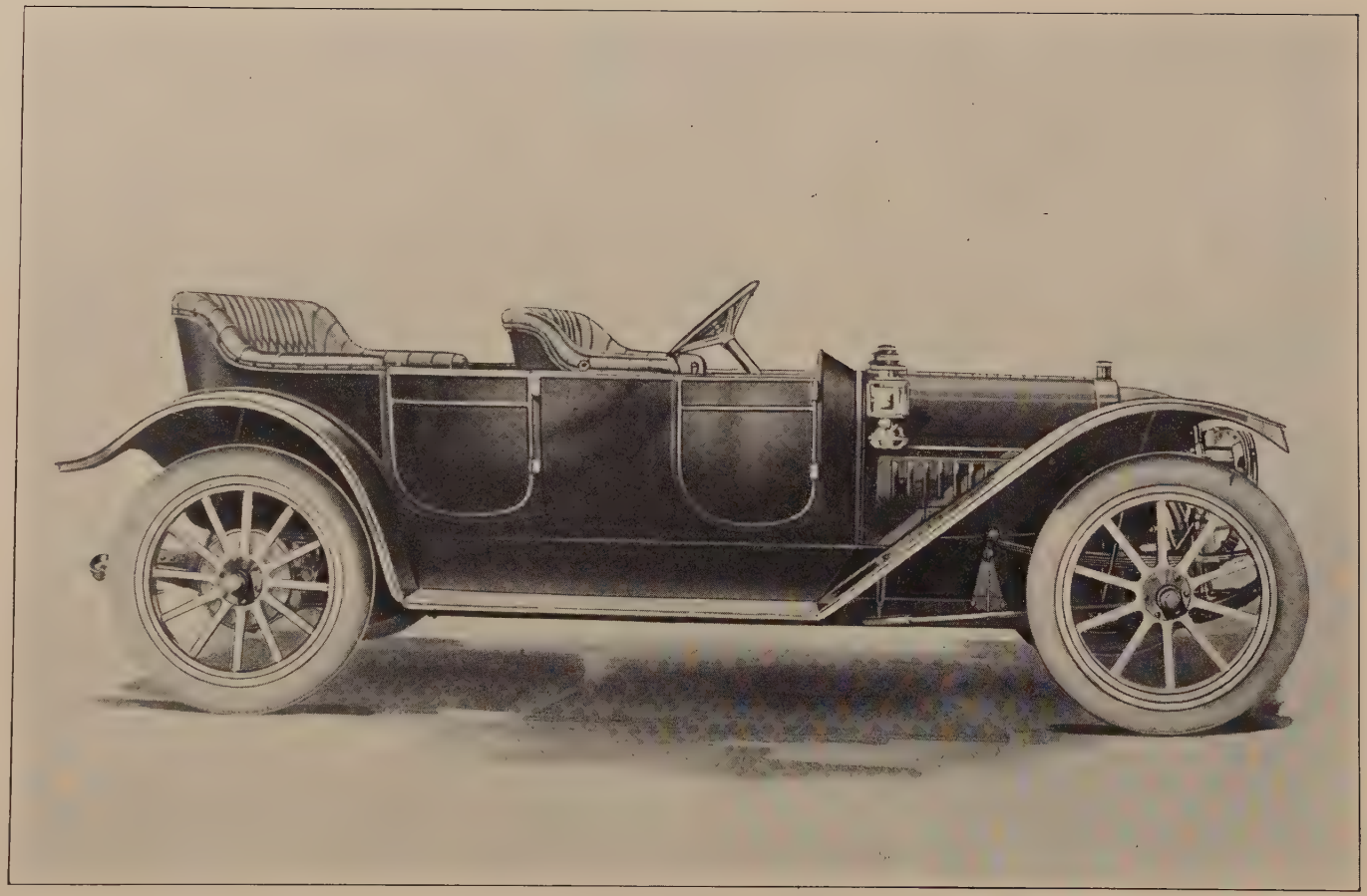
Changing Gears. The last method of snubbing the forward progress of the car consists of nothing more nor less than slowing down by shifting to the *low gear,* in which, as will be explained later on, many revolutions of the engine are necessary to make one rotation of the rear wheels. In conjunction with this, a retarded throttle will lower the movement of the car to a veritable crawl. This is usually very handy to know and to utilize in the crowded streets of large cities, particularly in the downtown districts during teaming hours.

Having then mastered the numerous ways of stopping and slowing the progress of the car, including the one to be most firmly impressed upon the mind—that of shutting off the gas supply by retarding the throttle lever to the limit—the amateur driver can begin to consider something else, which would naturally be the process of starting and the routine of inspection which precedes it.

STARTING THE CAR

Method. The best way to go about this is to have a simple routine, which is always followed. In order to always do the same thing and in the same order, it is well to have a list of things to be done, which should be learned and always followed. In a short time the driver will do these things unconsciously each time before starting out, and then the simple system will have served its purpose.

Now as a suggestion, one might say to oneself, what are my wants? and, after having attended to them, have I got everything? The key words to these two simple questions are the words WANTS and GOT. Taking these as the keywords, it is possible to lay down



REGAL MODEL H UNDERSLUNG TOURING CAR
Regal Motor Car Company, Detroit, Michigan

all of the things that should be done before starting, so that every letter of these two words represents one thing, as follows:

W ater
A cetylene (or lamps)
N uts and bolts
T ires
S park retarded
G asoline
O il
T rying out

Water. From the above, water stands for the question, is the water cooling system completely filled, or does it need any more water?

Acetylene. Then comes the question of proper lights—is there sufficient fuel to light the car on its way, whether it be acetylene compressed into tanks, generated from carbide, or just plain oil; or in the modern electric method is the lighting system complete.

If a gas tank is used instead of a generator, the autoist should see that the pressure gauge indicates that there is sufficient gas in the tank for the trip, and, if not, the tank should be replaced by a charged one.

In connection with filling the lamps it would be well to form the habit of wiping the tail-lamp glasses and the license-plate with a cloth, as these are usually neglected and become obscured by dirt, and may subject the autoist to arrest for not having a rear light or a legible license-plate.

Nuts and Bolts. Next, it is wise to glance over the more important bolts and nuts to see if they are tight, or at least appear tight. At first it is well to go over them with a wrench, but later on this is unnecessary.

Tires. Now the tires represent a very important part of the car, one that is very expensive to buy and maintain, so that it is a good idea to get into the habit of glancing at all four tires before setting out on any kind of a journey. In particular, the inflation should be examined. Tire manufacturers say that 35 per cent of tire troubles are due to under-inflation. In this connection, the table of tire pressures, Table I, will be very useful. It may be used in connection with any kind of a tire-pressure gauge. There are a number of these gauges on the market, and the beginner should obtain one very early in his driving career, learning to use and rely on it.

TABLE I

Proper Pressures in Tires

Size of Tire	Pressure Recommended		Weight per Wheel	
	Front	Rear	Front	Rear
28 by 2½	40	45	225	275
30 by 2½	45	50	225	275
28 by 3	48	52	350	425
30 by 3	50	55	375	450
32 by 3	52	58	375	450
34 by 3	52	60	400	500
28 by 3½	55	63	400	500
30 by 3½	58	65	450	550
32 by 3½	60	65	500	625
34 by 3½	63	65	550	675
36 by 3½	63	68	600	750
30 by 4	63	68	550	650
32 by 4	65	70	650	800
34 by 4	68	70	700	875
36 by 4	68	72	750	900
32 by 4½	68	72	700	800
34 by 4½	70	75	900	1125
36 by 4½	72	78	1000	1250
34 by 5	75	80	1000	1300
36 by 5	80	90	1150	1375
38 by 5	85	100	1250	1500
36 by 5½	90	105	1400	1600
38 by 5½	95	110	1500	1700

Spark. To save his own body, or to be more specific, his arms and shoulders, the driver must retard the spark every time before attempting to start the engine, else a back kick will result and injury will surely follow. This is an important point and one that, like shutting off the gas in an emergency, should be memorized early. The importance of this may be judged from the statement, borne out by the reports of insurance companies, that 37% of all automobile accidents to either driver or passenger, are cranking accidents.

Gasoline. Surely, the engine has not yet been invented which will run without fuel, so it is of primary importance to have not only some fuel, but enough to complete the proposed journey. This then stands for the question, "Is the gasoline tank filled?"

Oil. Lubrication is of equal if not superior importance, for even if everything is right and ready to run, with plenty of fuel, to run it without lubrication is to run it for the last time, *i. e.*, a lack of lubricant (oil, grease, graphite) will ruin the finest machinery.

After having started the motor, the autoist should listen for any unusual sounds while it is running, and closely watch the sight-feeds on the lubricator, adjusting them if necessary.

Trying Out the Car. After starting the engine the autoist should take his seat, and, withdrawing the clutch, place the shifter lever in the position for first speed, release the brakes, and start the car by engaging the clutch gradually.

While the car is moving the brakes should be operated, first the hand brake and then the foot brake, and if any adjustments are needed they should be made at once. A trial of the brakes with the car running is more valuable than a number of trials with the car at rest.

If the gear-shifter lever does not work properly, or the clutch slips, the fact will be indicated, and adjustments can be made on the spot, saving the autoist trouble and humiliation on the road.

Things to Remember About Starting. Next to the points covered above, the most important thing for the beginner to learn is the proper method of starting an engine, and of holding the starting crank so as to render the process a safe one. These are very hard things to impress upon the novice, who thinks that starting consists of turning the crank—a very simple operation—until the engine responds and starts. This is very far from the real situation.

Method of Cranking. The proper and safe method of starting should be learned for there are methods in daily use which are not safe. Take, for instance, the ordinary way of cranking the motor. Most motors turn clockwise, that is, from left to right. Then, in starting, the ordinary driver, who has just "picked up" driving, grabs the crank with the *right hand* and pulls on it until the top is reached, then pushes it over the center, and the motor either does or does not start. In the latter case, he continues to pull it around. This method, whether right or wrong, may possibly work on a small engine, but wait until this plan is tried upon a large motor.

The driver, to crank in this fashion, must stand at the left and between the center of the car and the wheel or fender. At the top of the stroke, which is also the top of the circle of revolution of the crank, he is in a very awkward position. Worst of all, his arm is extended stiff, and a back kick will operate directly against it, as shown at the left in Fig. 5, and shown also in Fig. 6. In this

manner the arm is liable to be broken, or at least badly wrenched. In addition, the awkward position is such that the weight must be

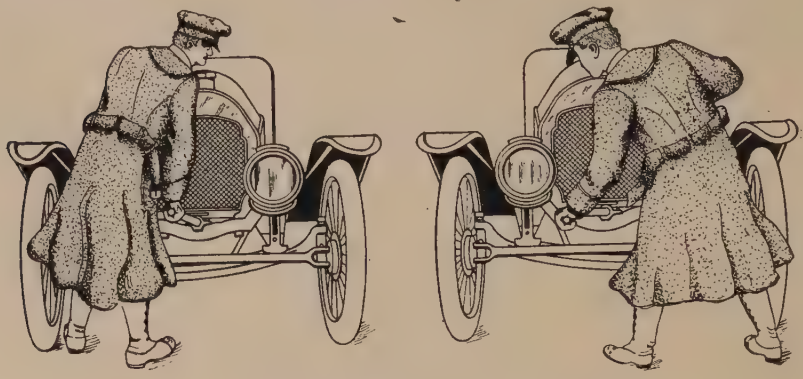


Fig. 5. Wrong and Right Method of Starting.

concentrated upon the right foot in order to balance. The least tendency toward back-firing is liable to destroy this balance, so that the driver may fall over. The writer has seen men start a car in this

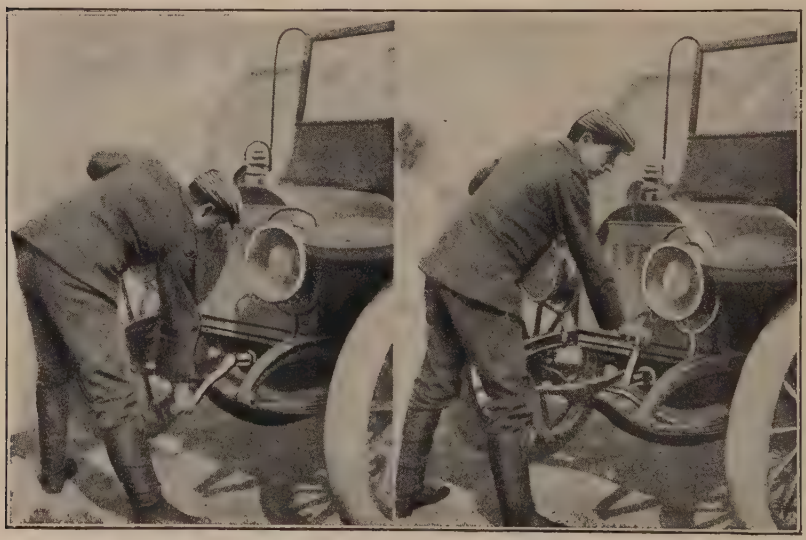


Fig. 6. Pulling (right way) Contrasted with Pushing It (wrong way).

fashion, and, finding the engine turn over more readily than they had expected and provided for, the very effort of starting was sufficient to upset their balance and cause them to fall over.

With *left-hand* starting, however, these three objections are obviated. As the turn of the crank is away from the center of the car, its movement may be counted upon to give the driver more room in which to stand. Instead of the last and hardest part of the cranking being in the nature of a push with the arms stiffened, it is more of a pull with the elbow flexed, and therefore free, as shown at the right in Fig. 5. If the engine back-fires it is easier to let go of the spinning crank, because it is exerting a pull on the hand, not a push as before. Then, too, the substitution of a well-balanced position for an awkward one helps to make the action of freeing the crank so as to let it turn freely, much easier. The advantages of left-hand starting, then, may be summed up as follows: less danger to the operator's arm, easier balance of the body, and less work.

How to Hold the Starting Crank. In the apparently simple operation of cranking an automobile engine there are many little points for the novice to consider. Among these the most important are those which make for increased safety. Thus the seemingly elementary action of grasping the crank handle is susceptible of two methods—one, right and safe; the other, not safe, and therefore, not right.

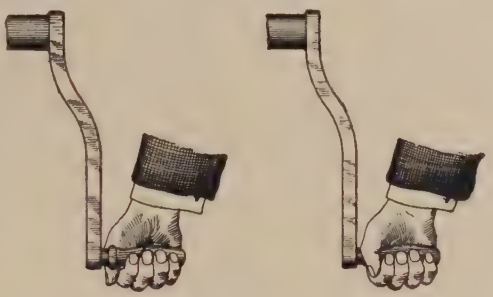


Fig. 7. Right and Wrong Crank Grip.

Ordinarily the driver will grasp the handle with a firm grip about as he would grasp a baseball bat; that is, with the fingers wrapped around it in one direction and the thumb around it in the other, as shown at the right in Fig. 7. Whatever method of cranking is employed, this grip is wrong, for if the motor back-fires the position of the thumb prevents letting go, at least quickly enough to be of any service.

The proper way, as shown at the left in Fig. 7, is to take hold with the fingers around the handle, but loosely, never tightly. Then the thumb should not be used at all, but should be folded back alongside of the first finger and out of the way. The whole work is done

by the fingers, and if anything happens the backward action of the crank simply opens the closed fingers and no harm is done. This holds true particularly when taken in conjunction with left-hand starting. In that case, the latter and dangerous part of the starting action is a pull toward the operator. The arm in which the greatest strength can be exerted, is in tension, So, if the engine back-fires, a person just stands still and holds the arm taut, while the backward action of the engine opens the fingers.

There have been a number of devices brought out to eliminate cranking, and with it, the danger, but very few of these have been

Fig. 8. Cranking from the Seat with an S-W Auto Crank.

commercially successful. The most successful modern mechanisms are all based upon a source of compressed gas—either exhaust or compressed gas on the one hand, or compressed air on the other. Then, there are a few mechanical devices, such as the strap starter, the various spring arrangements, and others, nearly all of which present much complication. A new device, which does not possess this fault and which is simple to attach as well, is the S-W *auto-crank*. This, contrary to the usual practice, is placed on the dashboard, and looks not unlike a coil box, except for the projecting shaft end, Fig. 8, Fig. 9, and Fig. 10. It consists of reduction gearing, thus giving the operator the advantage of mechanical reduction, which results in increased

safety. Then, too, the device incorporates an automatic release for use in the case of a back-fire, as well as for the prevention of backlash.

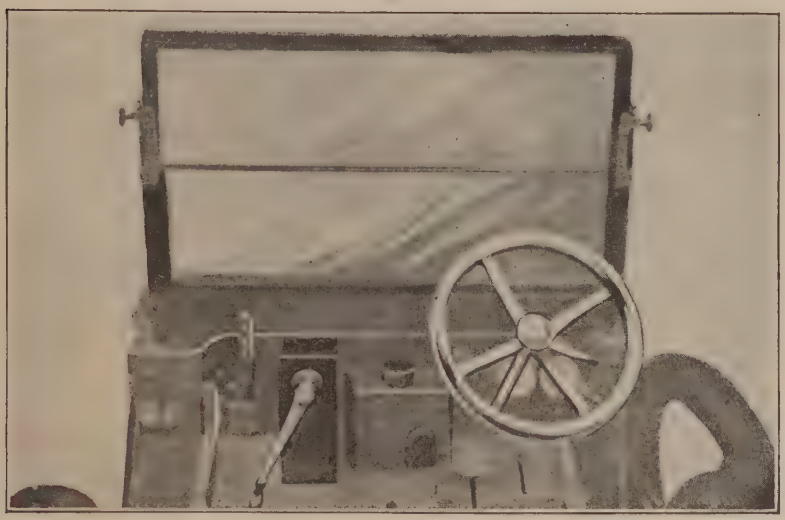


Fig. 9. View of Dashboard with S-W Crank in Position.

The automatic release comes into play when the engine is running normally, and under such conditions the crank does not rotate.

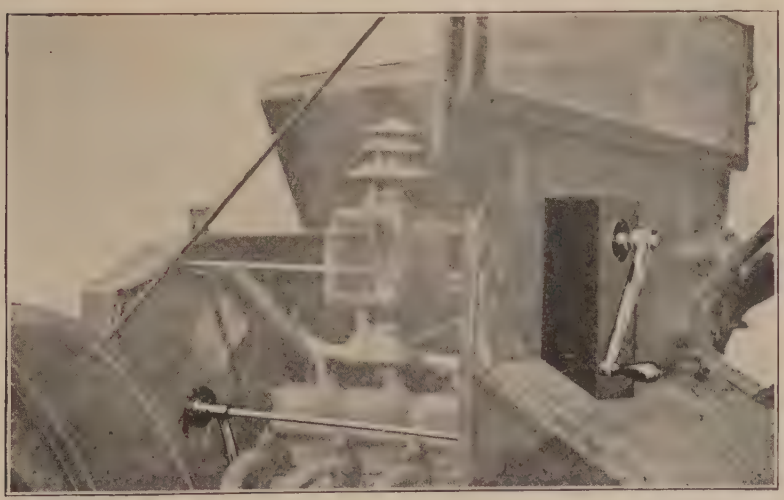


Fig. 10. Side View of Auto Crank Connections.

CONTROL

That one should master early the methods of control is easier to say than to do as is shown plainly in the two charts, Fig. 11 and Fig. 12. These depict the action of changing gears on a number of different American cars, and show at a glance the wide divergence in practice which the new driver must go up against. The upper figure is meant to represent the quadrants of cars having four-speed gears, and the lower figure, the quadrants of those cars fitted with three-speed gear boxes. By four speed and three speed, is meant respectively four forward speeds and three forward speeds; the reverse speeds, being taken for granted, are not counted in mentioning the number of speeds which the gear box affords. Thus, to call attention to a few of the types selected at random, *A*, Fig. 11—the quadrant on the Lozier Model G—has the reverse on the outside and forward, while the high speed is also forward but inside. The low speed is outside and backward, while a forward movement of the lever in the same line gives second speed. To attain third speed, when in high, is simply a matter of pulling the lever straight back. In *C*, Fig. 11, are shown the various lever positions on the Studebaker car. Again the reverse is to be found on the outside and forward but there the resemblance ceases, for the high speed is outside and forward, as compared with inside and forward on the Lozier. Low speed is inside and forward as contrasted with the Lozier's outside and back. Second speed is found inside and at the back as against outside and forward on the Lozier, and similarly with third, which is outside and back, instead of inside and back. This would lead to much trouble at first, as for instance, when a person who was used to a Lozier and was driving a Studebaker for the first time, was caught in an emergency, and dropped to reverse, desired to go into low, he would involuntarily go through the Lozier movement to which he was accustomed, namely, outside and back. This done upon the Studebaker results in third speed, which is very high as compared with the expected low. Sequel, an accident. Of course, this could only happen during the first few weeks of use of a new car, as after that time in any situation, it would be a matter of doing the shifting according to the quadrant of the new car. But to prevent just such a happening, the control should be mastered thoroughly, and learned so that one can

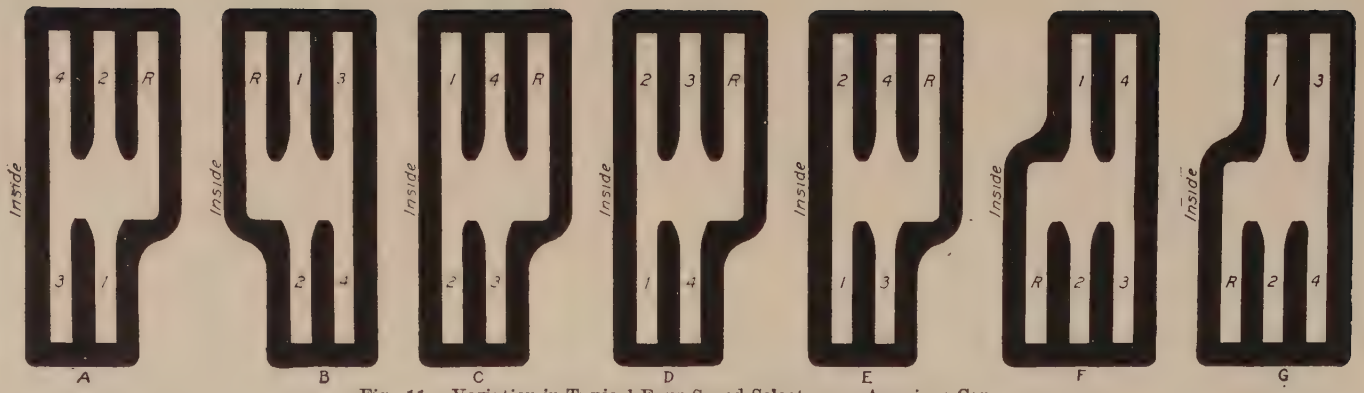


Fig. 11. Variation in Typical Four-Speed Selectors on American Cars.

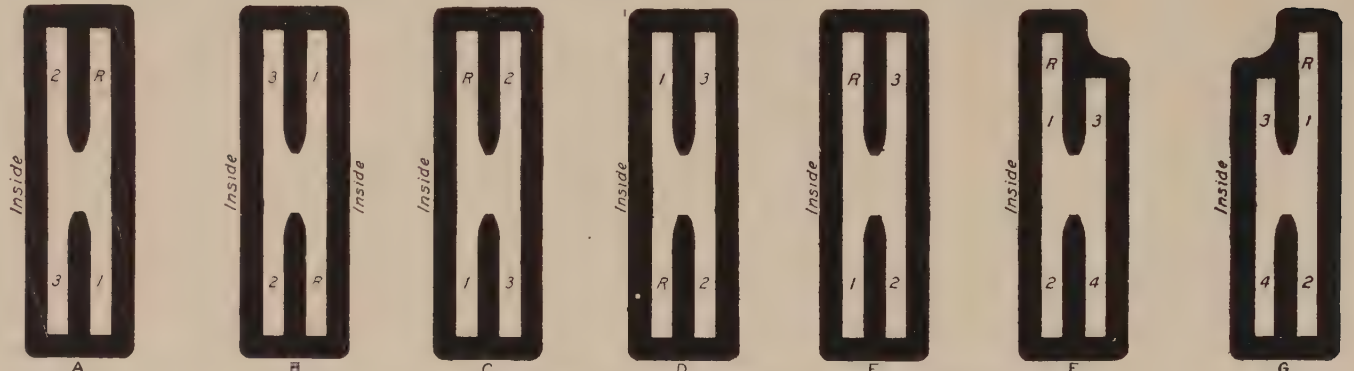


Fig. 12. Variation in Typical Three-Speed Selectors as Used on American Cars.

repeat upon request, the various speeds and the corresponding positions. Changing gears is at once a peculiar and a complicated action, for the clutch must be thrown out for an instant, during which the levers are shifted, after which the clutch is gently let in again.

Proper Procedure in Gear Changing. One thing that should be mastered early in the process of learning to change gears, is that the motor and the car should be moving at corresponding rates of speed. That is, when it is desired to change down from a high to a lower speed, if the car be allowed to slow down a little before changing, better results will be had. This may be effected by throwing the clutch out and holding it out for a short time, when the car will slow down a little. If this is done, the engine being free for a time, will begin to race and so the changing process must be accompanied by a closing of the throttle to reduce the engine speed. Similarly with changing from a low speed up to a higher one, the car should be moving rapidly, and the change should be made as quickly as is possible, so that the car does not lose any of its momentum. With the planetary type of gear, the matter of changing speeds is very simple, consisting of but a push on one or the other of two pedals, this action supplanting both clutch and change gear lever action on a sliding gear transmission. With this form, drivers usually guess at the proper period at which to make the change, any mistake in estimating the rates of the car and motor being of little consequence, as the bands will slip instead of transmitting the shock to the gear. A similar action occurs in the case of individual clutch or friction gears, but with the sliding type severe strains and shocks have to be taken up by the clutch and are usually transmitted in part to the gear if the clutch is not slipped. What applies to the sliding type in general, applies to the other types as well.

Changing from a Lower to a Higher Gear. In changing from a lower to a higher gear it will be necessary to speed up the motor by means of the throttle or accelerator in order to store enough energy in the flywheel to furnish the work needed to accelerate the car to its new speed. As the speed of the car increases the higher gear should be engaged, the autoist not being in too great a hurry to make the change; however, the movement of the change gear lever should be made quickly in order that the car does not lose way. When changing from a higher to a lower gear the change should be made so

quickly that the car has no time to slow down. When climbing a steep hill it should be ascended as far as possible on the high gear by proper use of the throttle and spark, and the change down to the lower gear made as soon as the motor begins to labor or is in danger of stopping. The presence of an unusual number of passengers in the car will affect its ability to negotiate grades which ordinarily are taken on the high gear, and the autoist should remember this and not attempt to force the car to travel on that gear with the increased load, but resort to a lower gear.

Changing with Selective Gearing. Of the two chief varieties of sliding gear the selective is in more common use. The most familiar form employs a sort of grid with communication between the two slots through a gate or passage cut in the bar at right angles to the slots. A lever works backward or forward in either of these slots and can be shifted from one to the other through the communicating gate. The ends of the slots represent the positions of the lever when certain gears are engaged, and in the illustration, Fig. 13, the lever is seen with the third or high gear in mesh. For changing from third to second gear the procedure is shown graphically. The first position is with the clutch engaged and the gear lever in third gear position, the clutch being shown above the grid. The second position shows the clutch disengaged and the lever being moved toward the second gear position, marked 2 on the grid. The third shows the lever in second gear position and the fourth, the final step in the change, the clutch again engaged. The procedure is the same in the case of a progressive sliding gear.

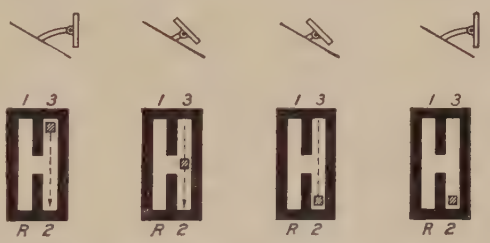


Fig. 13. Movement of Clutch Pedal (top) in Changing from Third to Second Speed (bottom).

Changing from Second to First Gear. Fig. 14 shows the change from second to first gear on the same grid, the upper line of figures showing the movement of the clutch pedal and the central line the corresponding movement of the accelerator, or throttle. The first position shows the clutch in and the throttle open ready for the change; the second shows the clutch withdrawn and the lever moved

along the slot until opposite the gate; while the third shows the lever being moved through the gate and along the other slot toward the first gear position, this sideways and forward movement being combined in one continuous movement. The motor having speeded up as soon as the clutch is released, it is necessary to reduce its speed somewhat before engaging the second gear, so the accelerator is shown partially released in this position. The gear is then engaged, the clutch let in, and the accelerator again depressed, which is the situation shown in the fourth position. A change from first to second is made in the reverse order, except that the accelerator pedal is not released unless it is necessary.

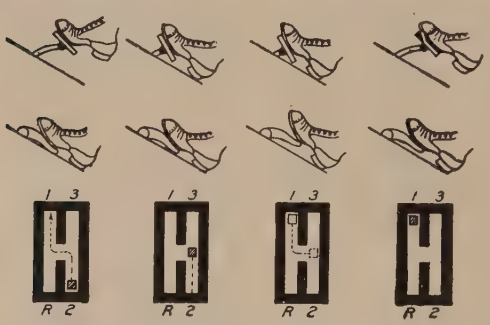


Fig. 14. Movement of Clutch Pedal (top) and Accelerator (middle) in Changing from Second to Low (bottom).

Use of the Spark. Upon the proper use of the sparking device depends the economy of the motor, and in many cases the safety of the driver. On some cars the sparking point on the magneto is fixed, and the autoist controls the car by the throttle only. There are a number of cars in use which employ the battery in connection with separate coils or a single spark system, or a magneto on which the spark can be regulated by the driver. When starting, the spark—in the case of battery ignition—should be retarded to prevent back-firing, and—in the case of magneto ignition—should also be retarded to a certain point, depending on the motor and magneto. When it is desired to slow the motor down below the point obtained by throttling only, the spark is likewise retarded. In ordinary running, a position of the spark lever can be found which will give fair average results through a considerable range of speed without changing its position, and this position varies with each motor and can be found by experience. When a higher rate of speed is desired, the throttle is opened and the spark advanced gradually. If a grade is to be negotiated it should be "rushed" if possible, the throttle being opened full and the spark well advanced until the motor begins to slow down

and "knock," when the spark should be retarded to correct this. The autoist should always keep the spark as far advanced as possible, without causing the motor to knock. When accelerating or retarding, the spark should follow the throttle, the latter always being operated first.

Driving at a Constant Speed. One of the best lessons on the proper method of driving a car is that of driving at a constant speed, no matter what the road conditions. The autoist should previously determine a speed compatible with the nature of all roads over which the car is to pass, and should see that the speedometer hand keeps at the determined speed throughout, regulating the spark and throttle and changing gears if necessary. Considerably more will be learned about the flexibility and power of the motor by driving in this way for a few times than by driving many times in the ordinary way.

Reversing is Usually Neglected. Among other things connected with driving which is apt to be neglected is reversing or driving a car backward. Usually a car is never reversed for more than a few yards at a time and the maneuvering involved requires no great skill. Steering a car when running backward is diametrically opposite to that when running forward. A turn of the wheel to the left steers the car in the opposite direction, to the right, and *vice versâ*. The usual mistake made in reversing is in turning the steering wheel too far and describing zigzags in the road as a result. The autoist should remember that *the reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.*

Systems of Control. Shifting a gear lever and pressing a clutch pedal does not constitute all that has to be learned about the control of a car by any means; in fact, to be frank, it is just a beginning. Each single action is of itself simple, as the sliding of gears, and the action of throwing out a clutch. So, too, is the throwing on of the brakes and the movement of the spark and throttle levers, but the really hard part is when it becomes necessary to do all of them simultaneously, that is—throw out the clutch, drop into low speed, throw on the brakes, shut down the throttle, and retard the spark: six complete and decidedly different actions at once, if both brakes be used.

As exemplifying the ordinary cases, several typical control systems will be shown and explained. The first, illustrated in Fig. 15, is that of the Chadwick car, a very large and powerful machine.

This has no less than ten components to the control system. First, there is the steering wheel, which governs the direction of the machine; second, is the speed lever, which controls the speed at which the machine can travel; third, is the emergency lever outside of the speed

Fig. 15. Complete Control Mechanism of the Chadwick Car.
Chadwick Engineering Works, Pottstown, Pa.

lever, and the most prominent in the illustration; fourth, is the clutch pedal, the one on the left; fifth, is the service brake foot pedal, which is placed at the right side of the foot board; sixth, is the foot accelerator, which is used to impart to the engine a sudden burst of speed, such as is necessary sometimes to cross a street ahead of a team—this is

located at the back of the right foot, so as to be manipulated by the heel of that foot when in its usual place upon the brake pedal; seventh, is the muffler cut-out, which is a very effective and rapidly working signal to teams and others in the street ahead; eighth, is the toe switch, by means of which the ignition may be cut off entirely; ninth, is the spark advance lever, which is placed with the tenth, the throttle lever, upon the upper interior part of the steering wheel. It is also obligatory upon the driver to sound the horn at all crossings, so that this might be put down as the eleventh item. So, the poor novice is bewildered with no less than eleven things to control at once, to say nothing of the motor itself, or its ignition, water supply, and number-

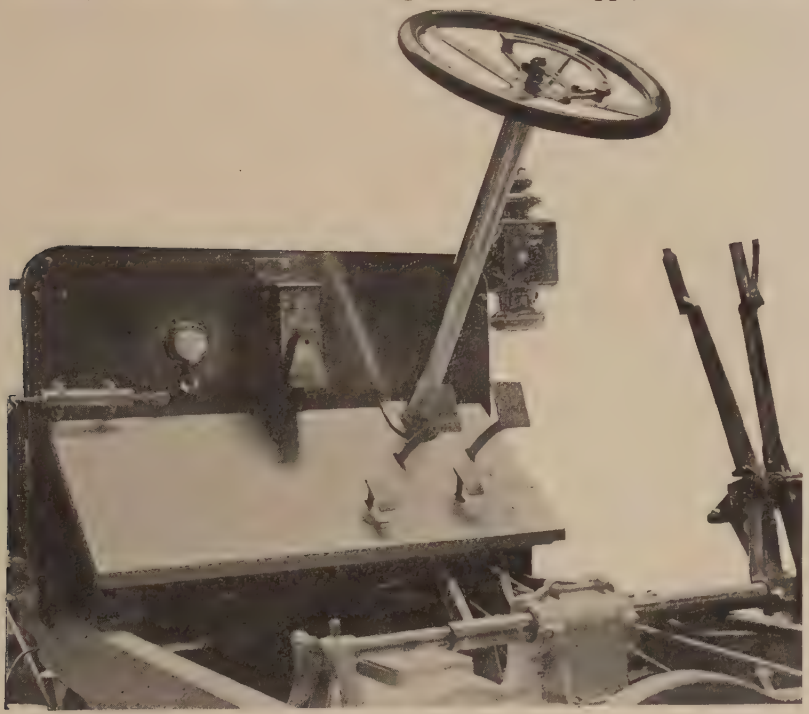


Fig. 16. Dashboard and Control Parts of the 40-H. P. Palmer-Singer.
Palmer-Singer Mfg. Co., New York City.

less other parts which might not work—in which case, the motor might stop or if it continued to run, might be ruined. Thinking all of these things over it is apparent that there will always be some people who will not and cannot learn to drive.

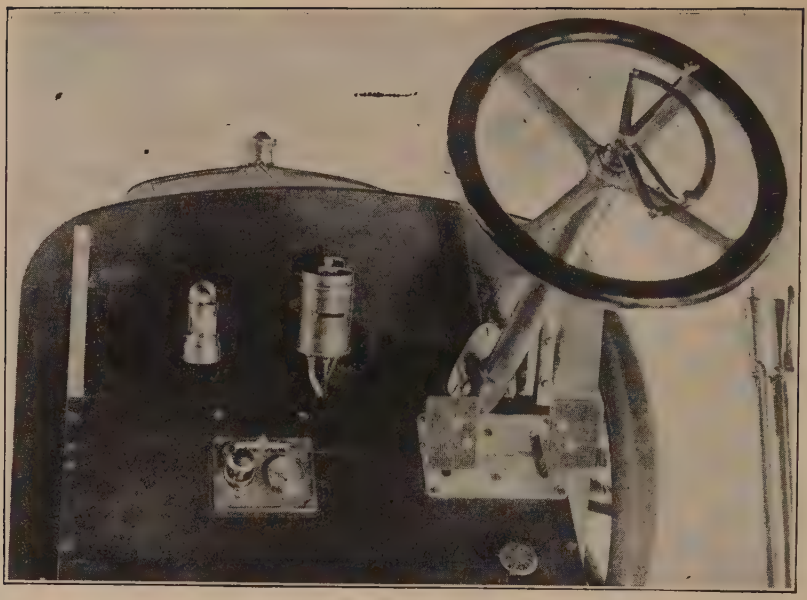


Fig. 17. Dashboard of the Lozier Little-Six.
Lozier Motor Co., Plattsburg and New York City.

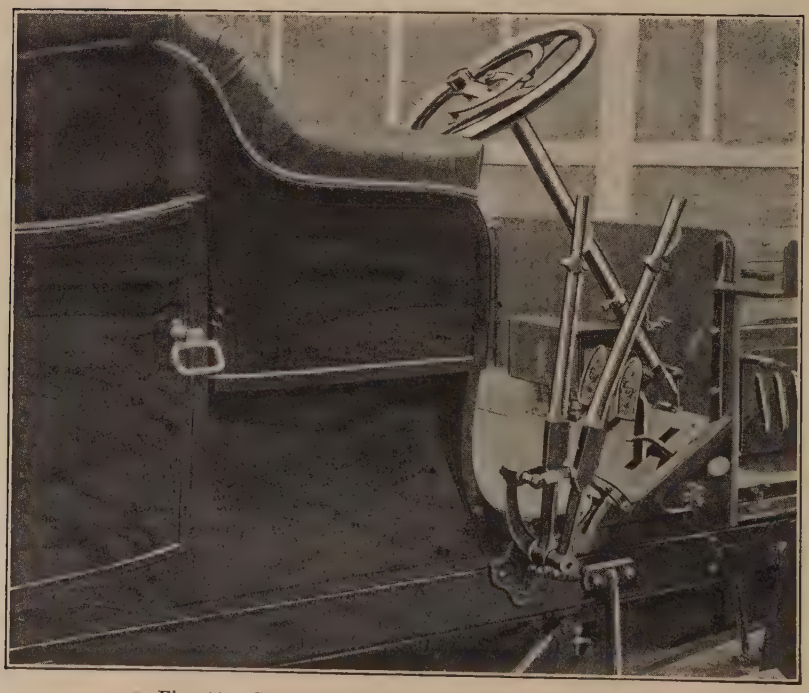


Fig. 18. Control Levers on the French Brouhot Car.

INDIANAPOLIS MOTOR SPEEDWAY COMING AROUND THE TURN IN FRONT OF THE GRANDSTAND

Another control system and its operating means is shown in Fig. 16, which represents the dashboard view of the P & S 40-horse-power machine made by the Palmer & Singer Mfg. Co., New York City. This differs little if any from the Chadwick, aside from the change in the spark and throttle levers, which are here placed so as to be operated by the right hand rather than by the left. All pedals have a rectangular section, but the mode of operation is the same. As differing a little more than this, the Lozier control, Fig. 17, is offered. In this it is seen that one pedal, the muffler cut-out, as well as the foot accelerator of the Chadwick, is missing. In its

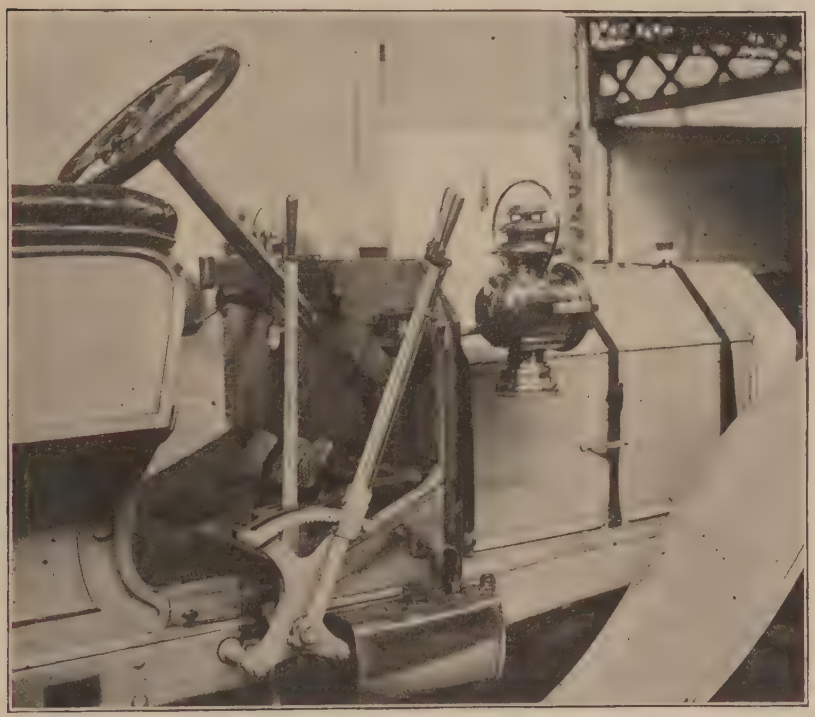


Fig. 19. View of Rochet-Schneider Car Showing Square Foot-Pedals.

place, however, there is a foot pump to maintain the oil pressure, this being seen at the left. To turn now to a foreign car, a marked difference is seen, as exemplified by the Brouhot car, Fig. 18, and the Rochet-Schneider car, Fig. 19. This latter shows three foot pedals of equal size, thus giving the muffler cut-out equal importance

with the clutch and service brakes. In addition, there is the foot accelerator, a smaller, lighter pedal at the extreme right. A hand lever on the dash may be used to increase the fuel pressure at any time.

Simplicity of Control. Nowadays, simplicity of control and the appearance of the dashboard are very essential features, and of

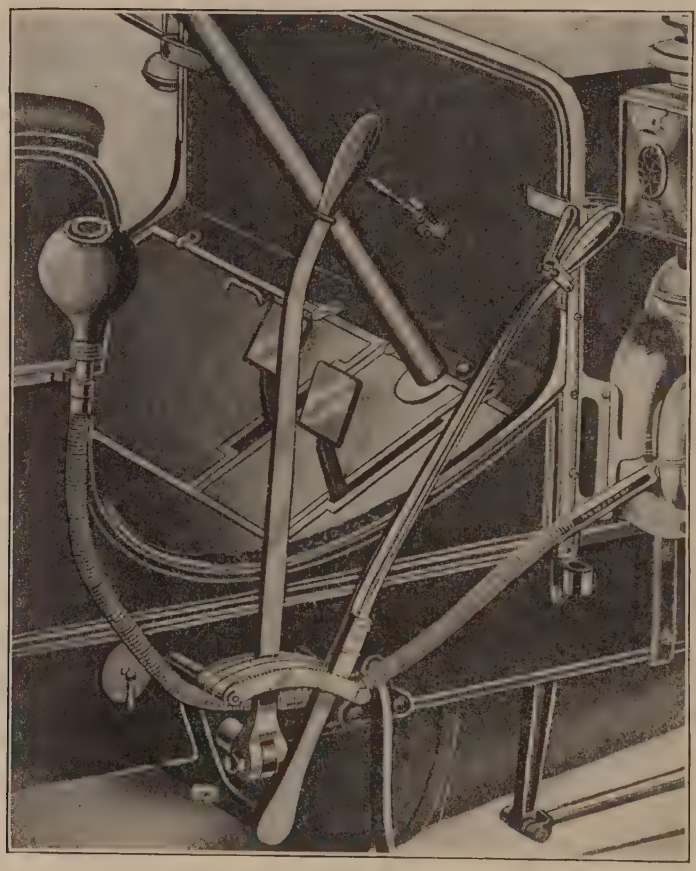


Fig. 20. Clean Dashboard a Characteristic of the Franklin Car.
H. H. Franklin Co., Syracuse, New York.

value in selling a car. On the Franklin, Fig. 20, this is seen to have been attained. There are but two pedals and two levers, besides the usual throttle lever. On this car, the spark lever has been omitted, owing to a special design of magneto. In many cases, the use of a pedal is said to be an easier, more natural act than the use of a lever

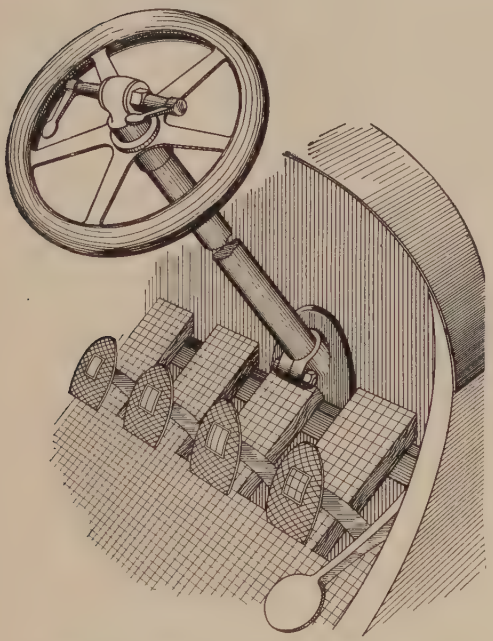


Fig. 21. View of the Adams, an English Car. No Side Levers.

operated by the hand. Taking full advantage of this fact, one English car, the Adams, uses pedals only, all levers being eliminated. Thus,

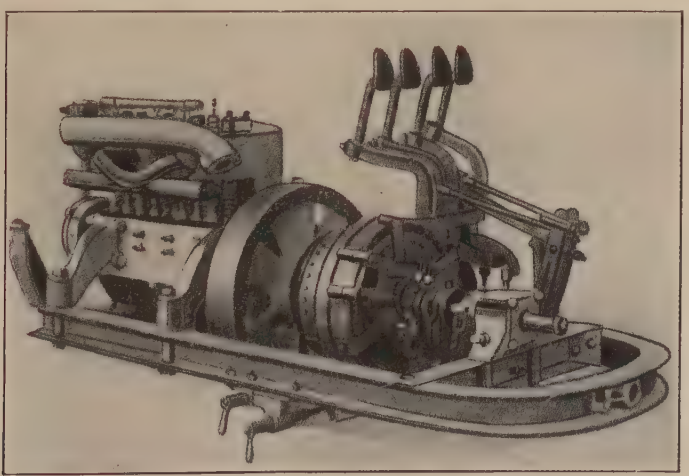


Fig. 22. Power Plant of an Adams Car.

as Fig. 21 shows, there are no less than five pedals to operate on this car. These are, respectively from left to right: reverse or brake, low speed, second speed, high speed, accelerator. The smaller cut, Fig. 22, shows how the connections of the pedals with the power plant are made. Not all hand levers act alike, as is brought out by the picture of the Stevens-Duryea control levers, Fig. 23. In this, it will be noticed that there is a small pin in the change speed lever, which slides in a slot. Normally it drops into a depression and holds the lever in place. To move the lever, it is necessary to raise this out of the groove. The smaller figure alongside of the levers shows just how this works.

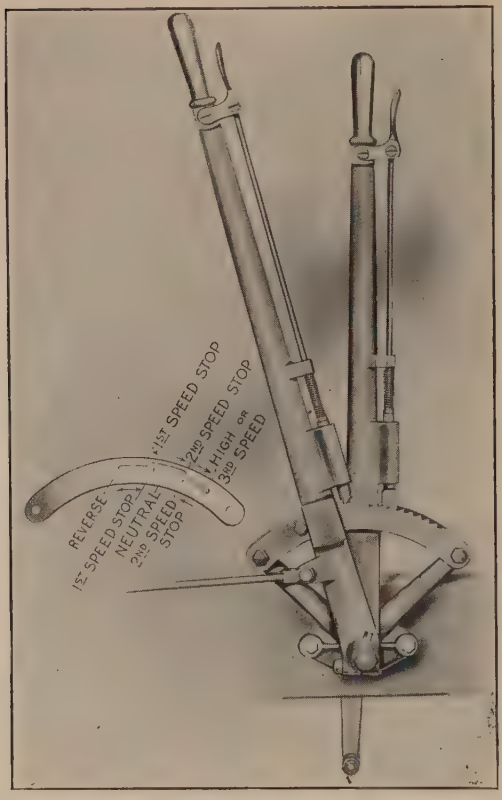


Fig. 23. Side Levers on the Stevens-Duryea Car.

As the method of imparting the use and action of these various parts to a novice is of some value, all of the schools teach it in a very thorough manner. Fig. 24 shows a scene in a Parisian school, L'école Centrale de Paris, where the instructor is demonstrating to some students the operation of the control pedals and levers, as just explained. One of the students is working the muffler cut-out. The car is a 40-horse-power Peugeot. Equally important is the actual application of this knowledge to the operation of a car. The way in which the latter is imparted is illustrated in Fig. 25 in which an instructor is showing a student how to change gears.

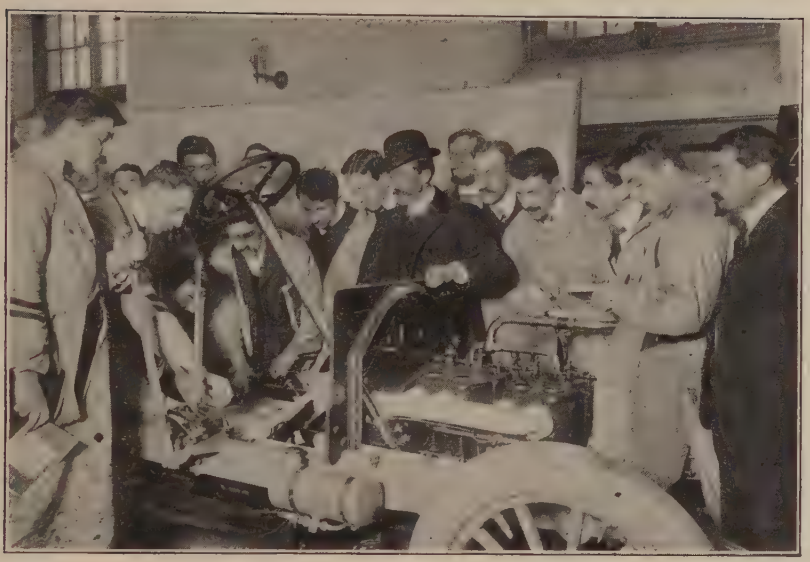


Fig. 24. Scene in a Parisian Automobile School.

STEERING GEAR

Mention has been made several times of the steering gear, and this plays a very important part in the operation of a car. Fig. 26 is a good illustration of the Peerless steering gear, and although it does not reveal the internal construction of the gear, it shows the operating lever at the base, the motion of which results in the movement of the wheels. The spark and throttle levers which connect directly to the magneto and carbureter respectively are seen, one below the gear, and the other near the top of the casting which holds the gear to the dashboard.

Fig. 25. Shifting Gears.

CLUTCH

One of the most puzzling sources of trouble is the clutch. The reason for this lies in the fact that it is seldom described to the novice,

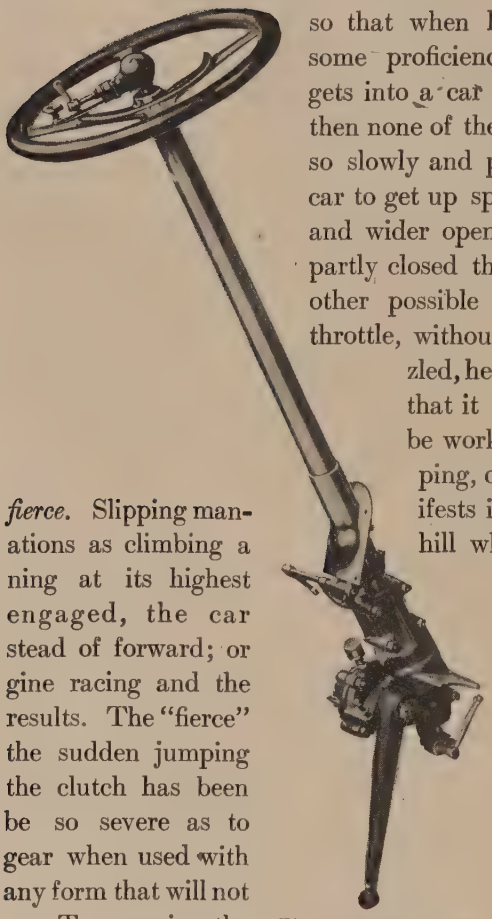


Fig. 26. Steering Gear of the Peerless Car.

so that when he thinks he has assumed some proficiency in driving, some day he gets into a car with a slipping clutch, and then none of the little things he has learned so slowly and painstakingly will cause the car to get up speed. He tries more spark and wider opened throttle, less spark and partly closed throttle, and all of the "57" other possible "varieties" of spark and throttle, without any result. Sorely puzzled, he appeals for aid, and is told that it is the clutch. This may be working properly, it may be slipping, or it may be what is called *fierce*. Slipping manifests itself in such pleasant situations as climbing a hill when, with the engine running at its highest speed and the proper gear engaged, the car starts to run backward instead of forward; or on the level, with the engine racing and the high gear in, no speed results. The "fierce" condition shows itself in the sudden jumping forward of the car when the clutch has been let in, and it may even be so severe as to shear off the bevel driving gear when used with studded non-skid tires or any form that will not slip easily.

To repair the slipping clutch, see if the surface of the leather is in good shape but has lubricating oil on it. If so, wash the surface well with gasoline, and roughen a little with a coarse file.

The harsh or fierce clutch is remedied by the application of a proper oil for this purpose. Castor oil is universally used and a good way is to soak the complete clutch in it over night. This will cure a case of harsh leather, but it may be that the trouble is only a lack of adjustment of spring tension. Usually there is an adjusting nut and a locking nut. Back off the latter and make an adjustment, then tighten the lock nut to retain it. For the beginner, it is better to adjust a little at a time and make several succes-

sive jobs of it than to try to do it all at once. But always adjust it as soon as possible.

CHAINS

While there are not as many chain-driven cars as there were formerly, still there are now and always will be a number of the highest powered cars driven by the double-chain method. This is an efficient drive, mechanically considered, but has fallen into disfavor, because of its noise and dirt. Both of these, however, can be reduced to a minimum.

The owner or driver of a chain-driven car should learn very early in his driving career to care for the driving chains in a proper manner. While chains have been known to run an entire season without any care or additional lubrication, this practice is to be deprecated. To care for a chain properly, one should get into the habit of lubricating it at such intervals that they occur before the chain is in need of the oil. In addition to this regular lubrication there should be some set time at the end of which the automobilist takes the chain off, cleans it thoroughly, and inspects it in order to detect faults. A month is a good length of time for this. An excellent way to proceed is to take the chain off and let it soak in a pan of kerosene over night. By morning, all of the dirt will have passed from the chain to the liquid and can be found at the bottom of the pan. Clean the pan and put the chain in it and wash off with gasoline all traces of the kerosene. Having done this, hang the chain up to let the gasoline evaporate.

The chain then will be both clean and dry. Now inspect all rollers, links, rivets, and bushings, taking note of any unusual wear as indicated by looseness or play. If defects are found, they should be remedied. Then, having the chain clean, dry, inspected, and passed upon as O. K., an excellent method is to soak it, or, better, boil it in a heavy melted lubricant. The best quality of beef tallow mixed with a little graphite is good. Many do not like the latter, in which case a high-grade oil may be substituted.

LIGHTING SYSTEM

Any part of the car liable to be put to use should have intelligent care. Thus, the lighting system is used only at night, but should

be kept in first class order at all times, so that when night falls, the whole system will be ready to go to work at once.

Care of the Generator. The interior of the carbide chamber or basket is more or less in contact with the water distribution apparatus and the parts of both apparatus are liable to clogging by the formation of lime residue in the generation of gas. If this residue is allowed to collect, it will have to be removed with a chisel, which is a ticklish operation in a light construction like that of a generator, especially around the water valve or its outlet. Acids are sometimes used to remove the deposit, but as they eat the metal, their use should be prohibited. The basket and pot should be thoroughly washed out after each run with water, the water outlets being cleaned with special brushes, when these are obtainable, or by wires, to remove all traces of lime. The water valve should be scraped and tested to see whether it seats properly, care being taken not to damage the valve or its seat in so doing. While the valve is dismounted for cleaning it would be well so see that its stem is straight and that it works with some ease in the threaded portion attached to the water chamber. The gas valves should be cleaned and should seat snugly, so that there will be no leakage past them. This applies also to the gas valves on the lamps.

The best position for the generator is on the running board just back of the change-gear quadrant, and sufficiently far out from the frame to allow a free circulatoin of air all around it. The generator will keep cool in this position and will perform its work to the best advantage when properly cooled.

The Much-Neglected Condenser. When used at all, the condenser or its substitute is put off in some position where it becomes caked with mud and is almost forgotten until it is full and the lamps begin to flicker. Then the mud is cleaned from it and it is drained out. It should be placed so that it is close to the lamps, where it will catch all of the condensation from the gas going to the burners, and in addition any water that may enter the burners due to washing of the car. It should be emptied from time to time, say once or even twice a month, when the lamps are in regular use. The majority of troubles with acetylene lamps are due to lack of a condenser and to the use of too small metal tubing.

Regarding Tubing and Gas-Bags. Copper tubing is considerably

used for piping the gas to the burners, but it is liable to erosion by the gas, and standard $\frac{1}{8}$-inch iron gas pipe is better and lasts longer. The gas-bag and rubber lamp connections should be kept clean and not painted, as is often done to correspond with the car, as paint rots the rubber, with the result that it is soon unserviceable and must be replaced. When the rubber is to be washed, only water should be used and the goods should be carefully dried before putting them in service again.

Care of the Lamp. It goes without saying that the burners should be kept clear, wires being passed through the gas apertures and the air apertures at intervals. The burners should be unscrewed occasionally, air blown through, and the interior of the burner body scraped clean of deposit. Outside of keeping the lenses and glasses bright and polishing the exterior of the lamp, there need be no other attention paid except to keep all joints and the bracket screws or nuts tight.

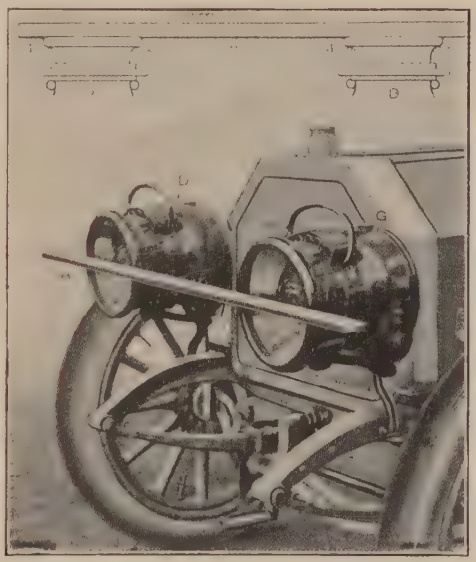


Fig. 27. Method of Aligning Lamps.

Caring for Acetylene Lamp System. As there is little night running during the winter months, the acetylene lighting system is more or less neglected, the generator being left with stale or partially used carbide in the chamber, and the residue being allowed to clog up the water port and the waste ports. The rubber lamp connections and gas-bag suffer also by deterioration as well as the burners and gas valves. For the proper maintenance of the system, strict cleanliness should be maintained at all times and the various parts should be examined and replaced from time to time as necessary. The results of neglect are seen every spring in lime deposits which have to be removed by means of a cold chisel, in porous connections, and

in clogged burners which resist the cleaning wire and necessitate the scraping of the burners. By following the accompanying directions, the automobilist can depend on having his lighting system in good shape whenever he desires to use it.

Lining up Lamps. If there is anything which is more noticeable than lamps out of line, *i. e.*, one farther forward than the other, the writer has failed to notice it. Drivers can avoid this "sloppy" appearance of their cars by simply taking a five-foot straight edge, and lining the lamps up in a proper manner, Fig. 27. This does not need to be done often, for the lamps do not work out of position, so if well done at first, it will always appear well. Since the lamps have considerable breadth, and may be assumed to be made square, by placing one and fastening it, the straight edge will indicate the proper position of the other. With that placed, the straight edge may be called upon again, to decide if they line up correctly. If they do, tightening the bolts locates the lamps so that they not only look right but are right.

ROAD REGULATIONS AND PRECAUTIONS

Early in his driving career the novice should cultivate a sense of fairness toward other drivers of automobiles, toward vehicles other than automobiles, and toward pedestrians. There is too little of this, and it may be said without fear of contradiction that this absence has done much in the past to retard the development of the automobile in rural districts; in fact, it has brought out a feeling of antipathy there which is but now being dissipated.

Passing Horses on the Road. The majority of horses encountered on roads frequented by automobiles to any extent, pay comparatively little attention to them, even when passed at fairly high speed, and of the remainder it is safe to say that most are not nearly so alarmed as their drivers, who communicate the alarm to the horses through sawing on the bit, shouting, or dropping the reins. The exceptions are young horses or those which have not been given sufficient road driving. In passing horses, the autoist should not only observe the actions of the horse, but also those of the driver. If the horse exhibits signs of being restive, the voice has a very quieting effect. Expressions such as "Whoa, boy," said in a reassuring tone will, in many cases, be sufficient to soothe the animal until the car can pass.

The best manner in which to pass a standing horse headed in the same direction as the car is to cross to the far side of the road and drive by quietly at the legal speed. The horse will be only slightly startled, if at all, and will not bolt or back, as the alarming object and its terrors are gone. More care is necessary in passing a horse headed in the opposite direction, as the animal can see the car coming and has time to become fidgety. If the driver has the animal under control, the car can be driven past at the regular pace unless signs of fright are seen, when the car should be slowed down, or stopped if necessary. The car should pass on the opposite side of the road and as soon as it is by, speed can be increased in order to get out of hearing as soon as possible.

Procedure in Leading a Horse. It may be necessary in some cases to stop both car and motor and to lead the horse past the car. A number of accidents have occurred in so doing by the horse freeing his head from the bridle through improper leading. Both reins should be taken in the right hand, Fig. 28, about 6 inches from the bit and the horse patted and reassured by the voice. The autoist should then *face forward* and start off, walking alongside the horse's head until past the car. Should the animal rear, the grip on both reins prevents him from tearing free from the bridle and bolting. The usual mistakes made in leading are in grasping one rein only—which hurts the horse's mouth and may break the bridle—and walking backward while leading the horse along. As a horse will not willingly walk over a man and as this is the position usually assumed by drivers when hitting the animal over the head, the operation instead of having a soothing effect, alarms and confuses him. Another situation requiring care is shown in Fig. 29.

Fig. 28. Correct Method of Leading a Horse.

Caution Needed in Overtaking Vehicles. There are two general principles to be remembered in overtaking or passing vehicles on the road. These are: Be sure that there is a clear way ahead before the overtaking or passing is attempted, and never cut things so fine

that a swerve on the part of the other man will cause a mishap. Quite a large proportion of road collisions come from either of the parties concerned taking chances that the other will do the right thing, which seldom happens. In overtaking another vehicle, care should be taken to ascertain that the driver is aware of your presence, particularly if he is driving a covered vehicle or one that is noisy. It is often difficult to make the other man hear, and the chances of his swinging out are too great to warrant any risk being taken. A tendency on the part of the driver to turn off to the side of the road, apparently to let the autoist go by, may be the result of an involuntary pull on the reins or may have been done to avoid a bad place in the road, and this turning off is often followed by an equal swing in the opposite direction. In following a vehicle the autoist should not keep in the other vehicle's tracks, but should stand off diagonally so that he or one of the passengers in the car can see the road ahead and observe the actions of other vehicles. Sufficient distance should be kept so that the autoist can turn in behind the leading vehicle in case of the sudden appearance of others coming in the opposite direction. When the way ahead is clear, the autoist should pass as quickly as the nature of the road permits.

Fig. 29. Passing Cattle on a Country Road.

Passing Moving and Stationary Vehicles. The chief point to be remembered in passing moving vehicles is to always allow plenty of room for both. The passing of another vehicle so closely that there is hardly room for a sheet of paper between them, may be looked upon as brilliant driving, but sooner or later some one will miscalculate and an accident will occur. All passing should be done according to the rule of the road prevailing in the section of the country in which the car is being driven, as the great majority of road users follow this

rule, and in case of accident the vehicle which held to the proper side of the road is generally exonerated in the courts. In passing stationary vehicles or those about to start, a strict lookout ahead should be kept for pedestrians or vehicles suddenly emerging from the rear, or in the case of a trolley car, for alighting passengers and those rushing to board the car. It is not sufficient to blow the horn and count on its being heard by those behind the other vehicle. The chances are that the sound has not been heard, and nothing but slow speed can be indulged in with safety. The same need of slow speed and extreme caution occurs in overtaking stationary vehicles as in passing them.

Passing on the Wrong Side. As a rule, all vehicles should be passed on the proper side according to the rules of the road, but there are occasions when it is unsafe to pass in this manner and the autoist has either to pass on the wrong side or to wait until conditions are such as will allow him to pass according to rule. Such an occasion often presents itself in overtaking a heavily loaded vehicle or one which has been disabled and has not been withdrawn to the side of the road. Once a loaded van or truck leaves the crown of the road, it has some difficulty in getting back again, especially if drawn by horses, and the driver will generally refuse to turn aside except for other equally heavy vehicles. As the autoist is conducting a vehicle of superior speed and mobility to that of the truck, the latter can be considered as a stationary object for the time being and passed on the wrong side, provided the road is clear. The situation is shown in the sketch, Fig. 30, where *B* is a truck and *A* is a car about to pass the truck. The road being clear, car *A* can take the course *b*, passing the truck on the wrong side. Should course *b* be taken, a collision is likely to occur between the car and another car *C* proceeding in the opposite direction, unless great caution is exercised by both drivers. If there is any doubt as to the road not being clear, the autoist should take no chances but wait until the way on the left of the truck, course *a*, is clear and then pass on the proper side. Situations like the above occur from time to time on the road and the autoist should use his judgment in coping with them. Legally it is not justifiable to depart from the rules of the road except to avoid accidents, and this should be borne in mind at all times.

Proper Negotiation of Road Crossings. In approaching road crossings the autoist should slow down to a speed at which he can pull up on the brake within the length of his car, and blow his horn for the purpose of warning other road users of his presence. As the car approaches the crossing, a sharp lookout should be kept for traffic on the intersecting road, and as soon as the way is seen to be clear the crossing should be taken as quickly as possible. Particular care should be exercised at crossings where one road is partially or totally hidden from the other until the crossing is reached, especially in the smaller towns, as light carts, bicycles, or, in fact, vehicles of any kind frequently emerge from the side road at speed and in the most careless manner, even when those in control are unable to see anything that is approaching on the main road. In anticipation of such performances the car should be kept to the center of the road so as to be able to turn aside to avoid a collision, for if the horn has been blown, there is no way of knowing that the driver of the other vehicle has heard it. Even if vehicles on the intersecting road can be seen, great caution must be exercised, as there is no indication that they are going to continue along the side road nor in which direction they will turn into the main road. Passing partially hidden road crossings at speed is absolutely dangerous because of the long chances which reckless autoists take at such places.

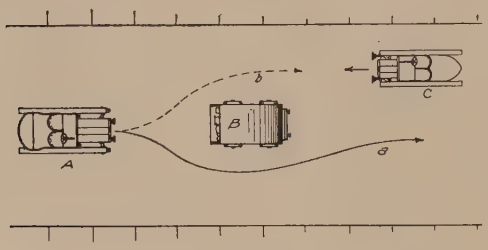


Fig. 30. Case Where Passing on the Wrong Side is Excusable.

On Approaching a Blind Turn. Frequently encountered in suburban towns is the blind turn, where a cross street or road terminates in one of the main roads and the view from either road is obscured by buildings or fences until the turn is reached. At such turns the chances of accident are greater than at road crossings, as at these latter places an autoist has three directions in which he can turn to escape collision, while at blind turns there are but two, with the chances in favor of the car on the side road. Referring to the sketch, Fig. 31, *A* is a car about to enter the main road and proceed thereon in the

right-hand direction, and *B* and *C* are cars coming along the main road. Owing to the high fence on one side and the building on the other, *A* cannot be seen from *B* or *C* until the lines *ax* and *bx* are reached, neither can *B* nor *C* be seen from *A*. The sound of a horn from either road likewise cannot be heard from the other. Under the circumstances, car *B* should keep to the center of the road as in negotiating road crossings, and car *C* should keep to the right-hand side of the road and proceed cautiously. When the car *A* makes the turn into the main road, it should take the path shown by the dotted line, swinging well out to avoid a possible collision. Car *B* has thus an opportunity to turn aside and avoid *A*. Should *A* turn to the left into the main road, car *C* is in no danger even if the driver of the former car cuts the corner closely. The positions shown in the sketch should be assumed at all times when approaching a blind turn whether the presence of a car on the other road is known or not.

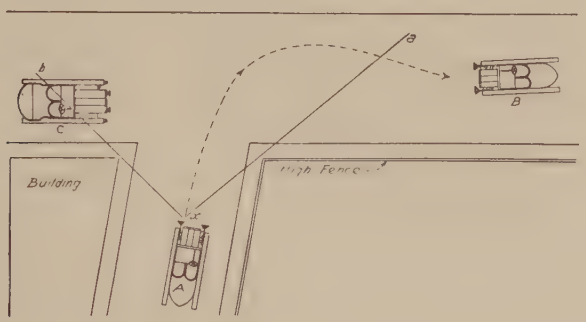


Fig. 31. How to Negotiate a Blind Turn.

The French experts consider the above an excellent argument in favor of the left-hand location of the control, *i. e.*, the driver with all of the steering and controlling mechanism located on the left rather than on the right. The way the argument goes is like this—a man sitting on the left can see farther around a blind turn like the one just described than a man located on the right. Therefore the driver placed at the left would be able to avert a fatal collision more easily.

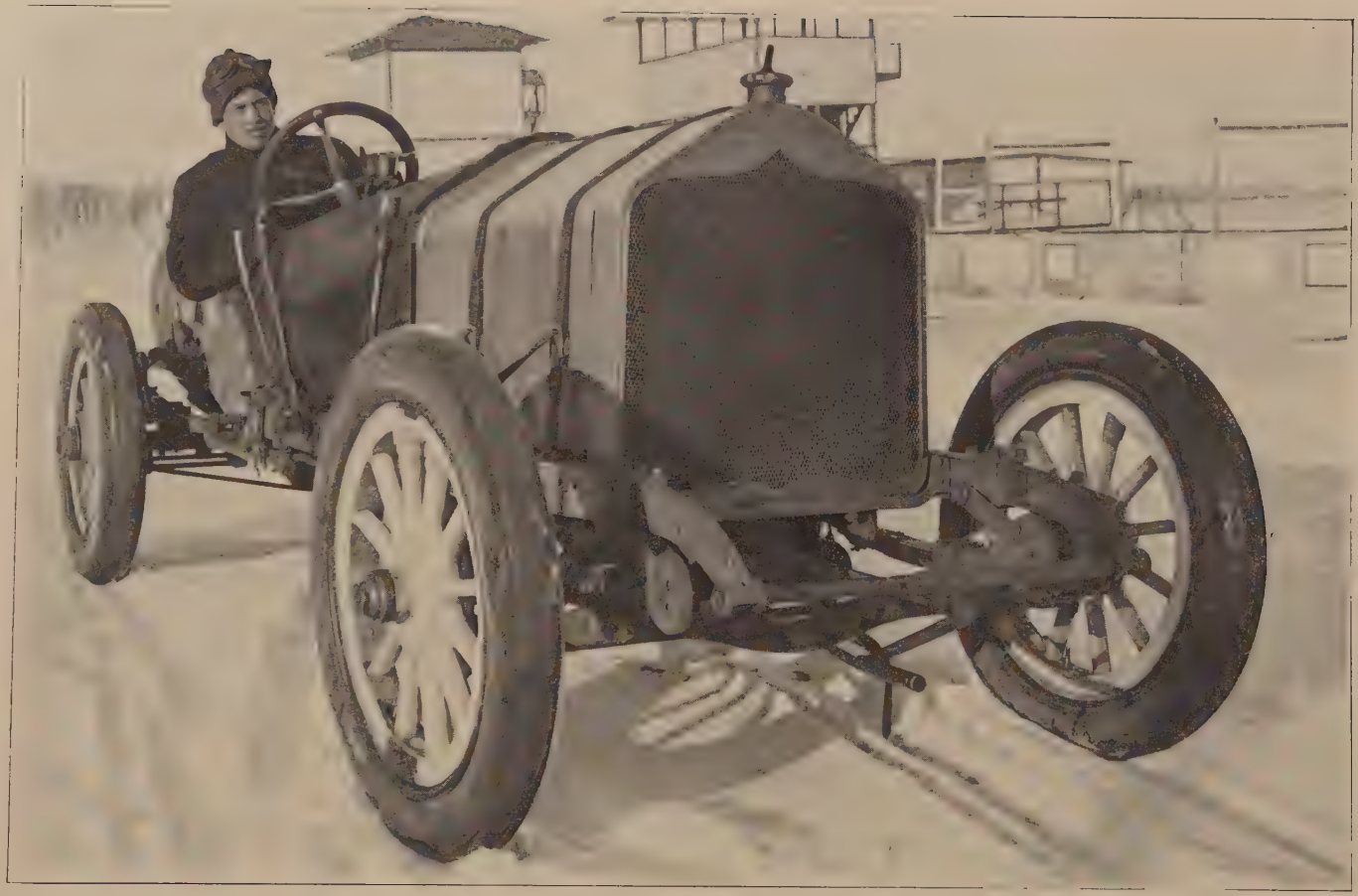
Be Careful Not to Get Boxed. In keeping religiously to the right when not passing a vehicle ahead—in which case the turn is to the left—the driver should be wary about being caught between a

vehicle ahead and the curb stone. Fig. 32 illustrates just such a contingency. As shown, the driver waited too long before turning out to the left, and so will have to stop and back away before he will be able to pass the obstructing wagon.

The Right of Way at Turns and Crossings. Regarding the right of way at turns and crossings, the vehicle which arrives first has the priority of passage according to actual road practice. In case of a "dead heat" between two cars, it remains for both drivers to agree as to which shall proceed ahead of the other, the driver yielding the way giving a signal with the hand. Generally speaking, horse traffic gives the precedence to automobile traffic as a matter of safety, but the autoist should not consider that he has the absolute right of way over all other road users for this reason. All users have equal rights on the road, but because the autoist has a vehicle of great physical superiority due to its weight and speed, he is not entitled to lord it over those not so well equipped. It does no harm to yield the road to a horsed vehicle even if the action necessitates a change of gears or a stoppage of the motor. On the contrary, the courtesy shown will do much toward removing the prejudice against automobiles in that portion of the country. In general, the autoist should exercise his discretion as to what is proper under the circumstances, departing from road practice if necessary, and his individual sense of fair play should cause him to have regard for the rights of others at all times.

Fig. 32. Result of Running too Close to Other Vehicles.

Negotiating Turns. The procedure on approaching a turn is exactly similar to that on approaching a road crossing. The car should keep to the center of the road and its speed should be reduced somewhat until the road is seen to be clear when the turn can be made. In taking a right-hand turn, the autoist should keep well away from the corner, describing as large an arc as possible and gradually gain-



HARVEY HERRICK, WORLD'S ROAD RACE CHAMPION IN A NATIONAL CAR
National Motor Vehicle Company, Indianapolis, Indiana

ing the center of the other road. Such maneuver is shown in the sketch, Fig. 33, where the car *A* follows the dotted course until the point *b* is reached. By so doing a collision with another car coming in the opposite direction will be avoided as either car can swing clear. In taking a turn to the left, a similar maneuver should be made, but in this case the car should keep close to the proper side, as in the sketch of the left turn. The size of the arc described in making the turn will, of course, depend on the width of the road and the length of the car, small runabouts being able to turn in an arc of 25 feet or less, while large touring cars should describe arcs of 32 feet and over on an ordinary road.

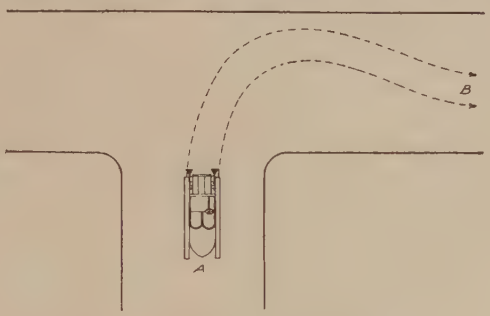


Fig. 33. Proper Turn to the Right.

Corner Shaving to Be Avoided. Except when absolutely necessary to avoid a collision, corners should never be cut closely or "shaved" as it is often called. By shaving a corner the autoist runs chances of colliding with other vehicles, and engenders a dislike in all other users of the road not only for himself but for automobiles in general. There are numbers of drivers that habitually shave corners, who start to make the turn before reaching the proper point and cut diagonally across the road, obstructing traffic coming in the opposite direction, and hugging the left-hand corner of the intersecting road. Their desire is evidently to travel from one point to another in the shortest possible space of time, and, to save distance, cut the corners without regard to the rights or safety of others. The majority of automobile drivers of this class luckily confine their operations to city streets, although they are found in some numbers on country roads. On the other hand a large majority of horse drivers are corner shavers, women being particularly given to the practice. Because of the presence of this and the reckless classes of drivers, special caution has to be exercised at all times by those in charge of vehicles of every kind, Fig. 34.

On Approaching a Road Fork. On approaching a point where

the road forks or branches off, the autoist should hold well over to the proper side of the road in order to avoid cars coming along the branches. Should he be traveling along one of the branches toward the fork, however, he should keep in the center, as when approaching an ordinary turn. On overtaking another car, it would be better to allow the latter to proceed on its course without attempting to pass, unless the driver signals the direction he is about to take. The reason for this can readily be seen by referring to the sketch, Fig. 35, where car *B* is about to overtake car *A*. If *B* attempts to pass *A* by taking the path *y*, a collision will occur if car *A* turns down the left fork at *a*. On the other hand, if the path *x* on the wrong side is taken, a collision will occur at *b* if the leading car takes the right fork. Hence the driver of *B* should allow *A* to take its course before proceeding on his own. If the driver of car *A* should signal the fork he is going to take, *B* can pass on the proper side if the same fork is to be taken by both, and on the wrong side if *A* is to take the left fork and *B* the right. If *A* is to take the right fork and *B* the left fork, *B* will pass in the ordinary manner.

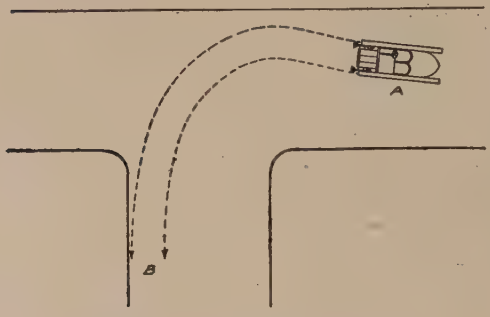


Fig. 34. Correct Turn to the Left.

As stated before, turns should be taken slowly, particularly, close to cities or towns. In the country, one is apt to forget this advice and whirl around the turn as if there were no turn there. An experience with a rapidly skidding car on a turn like the one shown in Fig. 36 will cure the driver of this habit. Here an open and fast road tempts one to speed. The curves are flat, and rounding them at speed, the car would skid to a very great extent and just where the

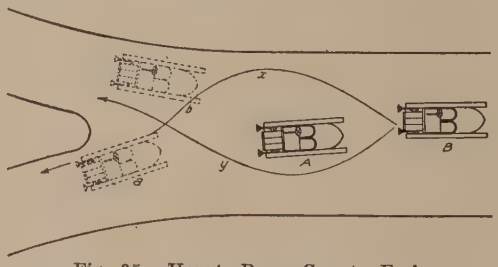


Fig. 35. How to Pass a Car at a Fork.

Fig. 36. Bad Turn Requiring Care and Slow Speed.

Fig. 37. Road Situation Requiring Slow Speed and Plenty of Warning.

skidding car will be sure to strike will be noticed a nice, soft (?) telephone pole. Another situation requiring slow speed and plenty of warning is shown in Fig. 37.

Under Bridges Sometimes Dangerous. Fig. 38 presents a scene of more than passing interest—one in which considerable danger to the autoist may be lurking. This is a case where a road leads under a bridge and the other end of the road turns away so that it may not be seen. That is, this represents two blind turns, with a bridge added to complicate matters. The proper procedure is to approach slowly, signalling loudly, until well under the bridge, when a slightly improved view of the other road may be had. If another car is approaching, it is an easy matter to stop, and if no other car or vehicle is in sight, it is an equally easy matter to throw on full speed.

Fig. 38. A Dangerous Road Situation.

Blind Courts Give an Opportunity for Skill. A driver who is skillful in maneuvering around has an excellent chance to show his skill, when caught in what is called a *blind court*. This is, as shown by Fig. 39, a court or street which has but one entrance and exit, the two corresponding. To get out it is necessary to back, come forward again, back and forward, until the car is moved around in the narrow court so as to be able to proceed in the reverse direction. In the figure, the first position is marked (1). From this, the driver perceiving his situation, turns as sharply as possible to second position (2). In stopping, the wheels are warped around in the opposite direction as far as possible, before moving the car—bad practice but needed here to save every inch. Then throwing into reverse,

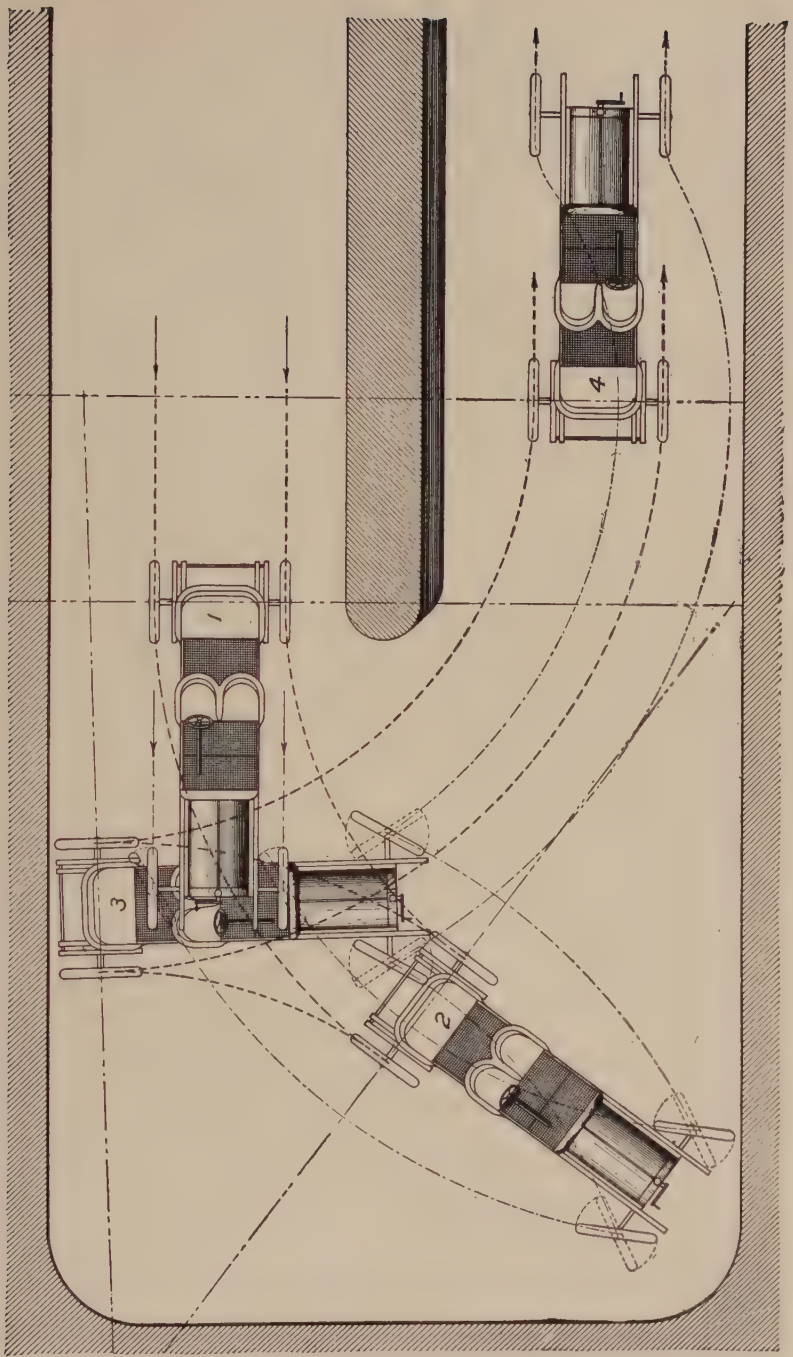


Fig. 39. Maneuvers in Getting Out of a Blind Court.

the driver backs up to the third position (3). From there, by cutting a very close corner, he is able to proceed out of the court. Position (4) shows the final position of the car, while the dotted lines indicate its movements. A narrower court would have called for more backing than this one did.

Volumes could be devoted to this subject, for the situations met with on the road are endless, as are also the combinations of cars, drivers, and corners. The driver should always be fair and render to others their half of the road, their share of time wasted and saved, as well as consider that they might have been as near right as he.

MECHANICAL FEATURES

The driver who wishes to know more about his machine than is necessary to simply run it, or the man who wishes to follow driving as a profession should approach the subject intelligently, and should learn as much about the mechanical side of the work as is possible. There are many ways of doing work, not all of them correct, and the man anxious to get along should learn the right ways. Thus, the subject of valves is very important, since leaking valves prevent the motor from doing its best work, and may even prevent it from working at all. This fault is certainly "up to" the driver of the car, just as much as if he deliberately broke a valve with a hammer.

Grinding the Valves. The new driver must learn when to grind in his valves, that is, how often, and he must also learn how to do the work properly. There is no hard and fast rule which can be given aside from grinding when it is necessary. A careful driver may get four to five thousand miles out of his valves with one grinding, while another may only get one or two thousand miles with the selfsame car and engine. There are many factors which enter into the life of a valve seat, and, in the frequency of grinding, all of them have to be taken into account. Some of these are: imperfect cooling of the seats; too strong springs, which cause hammering and thus wear out the seats prematurely; over-lubricating, which causes spitting and sooting, both of which reduce the active life of the valve seat.

Other causes are contributory negligence on the part of the driver in not examining them more often, which results in the failure to discover something in the way of soot or dust caught in between the valve and seat, which is being gradually pressed into the latter. Profes-

sional drivers grind valves as soon as a certain distance has been coverd, this being predetermined by experience with a single or many cars.

As far as the grinding action itself is concerned, that, too, is very simple. The tools needed are few and easy to obtain, consisting of a screw-driver and some emery, the latter the finest you can obtain. This should be mixed to a paste with oil, preferably a light cylinder oil. Now, have the valve free of its spring, clean the seat off, and spread a very little of the paste over it. Put the valve into place on top of the paste, and with the screw-driver or brace and screw-driver bit, as shown in Fig. 40, turn the valve on its seat about half a turn, then reverse, and turn back half a turn. All the time, pressure must be exerted upon the valve, so that the emery will take hold and cut. Then move the valve around to a fresh position, and repeat the alternate forward and back motions. The first and second positions will have covered the whole circuit, if just a half turn be used each time. In that case, the third move should be such as to grind on a space not wholly covered by the previous work.

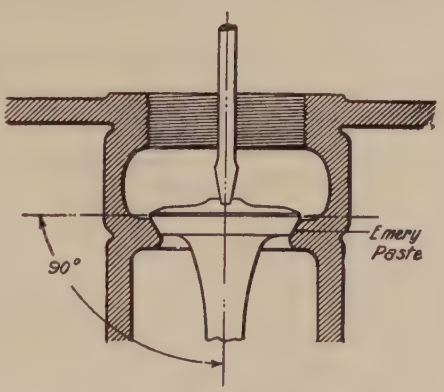


Fig. 40. Grinding Valve Seat.

Beyond this, the only really important point is to have the axis of the valve perfectly square with the seat. If the valve guide has become worn, there is danger of tilting the valve to one side during the grinding process. Then, when in use, it tilts back to the other side and the work of grinding has become useless. There is some danger of grinding off too much. To determine when you have ground enough, note when the pitting has disappeared. After that, grind very little longer before you test the set. This is done by coating the freshly ground seat with a thin film of red lead, or by smoking it with the flame of a candle. Having thus marked it, set the valve lightly into place and rotate. If you have ground to a proper seat, this rotation will scrape off the lead or carbon used in continuous ring. It does not matter how wide this ring is, but it must be continuous.

Taking Out a Valve. On some engines the job of taking out a valve or valves is not as simple as it sounds. On an overhead engine, or an engine with overhead valves, it is not as hard work as on an engine with the valves in pockets in the side of the cylinder, for the overhead valves usually are set into removable seats. The latter come out by simply taking off a yoke or at most, a pair of nuts, and then the cage and with it the valve lifts right out, spring and all. This latter is mentioned because with the ordinary ell or tee head motor, it is the spring which causes all of the trouble. Fig. 41 shows the process of removing the cage and valve from an engine with overhead valves—this is the Truscott engine made for the Truscott boats. To remove these, the valve tappet is held out of the way, and the cage unscrewed. Nothing could be simpler.

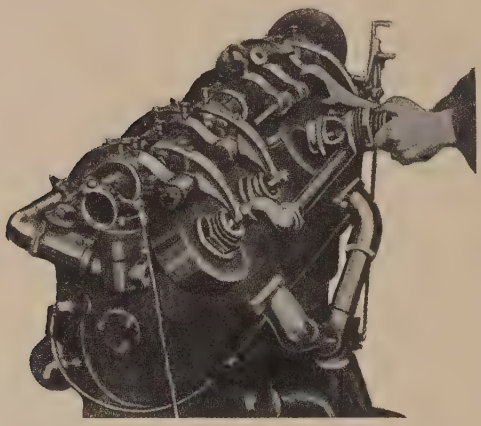


Fig. 41. Removing Valves from a Truscott Marine Engine.

Carbon Deposits. Cleaning an engine of carbon represents a very dirty job, one that is shirked as much as possible. The novice should learn the cause of formation of carbon deposits in the cylinders, and by avoiding this, get out of doing this dirty work. In addition, credit will attach to him for a better running engine. Carbon deposits are formed by the partial combustion of the excess of fuel or lubricating oil. To run with too little oil sounds like bad advice, but it will cure the sooting trouble, and should be practiced as soon as the driver becomes proficient enough to "monkey" with those things. When the engine misfires and in other ways shows the presence of carbon within the cylinders, the driver should seize the first opportunity to pull it down and clean it thoroughly. It has been said that this carbon could be removed by burning it off while the engine is running by means of kerosene. The kerosene together with the jarring action loosens some of it, but as far as burning it off is concerned, that is impossible, for the

carbon is a residue from a burning action. The best way is to use a decarbonizer or else take down the entire motor, scrape it clean, and then paint it with a very thin coat of paraffin. It is said that this will aid very materially in preventing the formation of more carbon.

The most important thing to learn about the formation of carbon is that it is caused by incomplete combustion, which also means fuel going to waste. Hence the motor should be cleaned and then run so as to consume the fuel completely, and thereby prevent the formation of scale in the future. This can be effected by proper care in selecting the oil used for lubricating the cylinders, the method of lubrication, and amount of oil fed in. Also, care must be exercised in the selection and use of the fuel, particularly the latter, as this may, in extreme cases, be such as to deposit particles of carbon in the cylinders. Care in this direction is well invested, however, as any autoist who has ever dismantled his engine for cleaning purposes can testify.

Carbon sometimes collects in the muffler, the effect of which may be illustrated by the following: In case of one automobile, it collected there until there was a large quantity of it, sufficient to obstruct the passage of the heated gases. The immediate effect was to heat up the muffler pipe until it was red-hot. This, in turn, transmitted its heat to the exhaust pipe which became red-hot. Finally this reached the cylinders, and the whole exhausting system beyond the cylinders was red-hot. The owner and driver of the car was at his wit's end to find the trouble, seeking it in the carburetion and ignition systems, of course without result. After working on the trouble unsuccessfully for some weeks, he accidentally hit the muffler a sharp blow. The dirt which fell out surprised him so much by its quantity, that he was induced to take the muffler off and examine it. Finding it very full of carbon, he cleaned it and put it back on the machine and no more trouble with hot pipes was experienced.

Oils. Mention having been made of oils above, it will be well to speak of these briefly. They must be purchased with much care. Once an oil is found which does the work satisfactorily, it should be adhered to consistently. No two oils are exactly alike, and for that reason, no two will do the same work under the same conditions in

the same way. So, it is advisable to experiment only until an oil is found which will do the work. Thereafter, stick to that brand. As an instance of the impurities which may be found in oils, acids may be mentioned. These are fatal to delicate and closely machined parts such as ball bearings, cylinder walls, pistons, etc., and consequently they should be watched for.

Pure mineral oils contain little acid, and what they do contain is readily determined. Vegetable and animal oils, on the other hand, all have acid content and under the action of heat this may be liberated.

Testing Oil. A simple home test may be practiced as follows: Secure from a druggist a solution of sodium carbonate in an equal weight of water. Place this in a small glass bottle or vial. To test an oil, take a small quantity of the lubricant, and an equal amount of the sodium solution. Put both in another bottle, agitate thoroughly, and then allow it to stand. If any acid is present, a precipitate will settle to the bottom, the amount of the precipitation being a measure of the amount of acid present.

Another method is to allow the acid, if there is any, to attack some metal. To do this proceed as follows: Soak a piece of cloth or, preferably, wicking in the oil suspected of containing acid. Select a piece of steel at random and polish it to a bright surface. Wrap the steel in the soaked rag or wicking, and place in the sunlight but protect it from wind or weather. Allow it to stand several days, and if there is no sign of etching of the surface, repeat with a freshly soaked rag, being careful to use the same oil as before. After two trials, if no sign of the etching appears, you may take it as free from acid.

As far as the oil is concerned, it may, in its passage around through the lubricating system, gather up much dirt. While the oiling system may contain a filter, it is not wise to depend upon this alone, but the pump should be removed occasionally and cleaned. Its condition will give positive proof of the ability of the brass gauze to remove the silt. On many of the modern cars, the pump is located at the bottom of the rear end of the crank case. In this position, it is removed by taking off a couple of bolts. The shaft, which drives it, is provided with a slip joint which allows of the removal and restoration of the pump, without dismantling the whole motor. Fig. 42 shows how a pump is removed from a crank case for cleaning.

The four nuts have been taken off, after which the driver reaches in and takes hold of the pump firmly. A steady downward pull draws the driving gear out of engagement, after which the other hand is used to steady the further downward movement of the pump. This is done carefully, as the superior hardness of the gear over that of the material composing the case, renders the former liable to scratch or scrape the latter.

Other Lubricants. Although no lubricant other than oil has been mentioned, the novice driver should not think that there is no other worth using. Grease and graphite find many places of superior application on the automobile, and their use should be a matter of study. Graphite, in particular, is and has been somewhat mystifying, for it is hard to explain why it is that such a small quantity of graphite will do as much lubricating work as a vastly greater quantity of other lubricating means, such as grease or oil. This is a fact nevertheless. Graphite has found much favor of recent years as an additional substance to be put into the lubricating oil. When thus used, it renders the surface of steel rotating parts hard and glazed so that they withstand frictional retardation better. More than this, the highly polished surface which graphite imparts in a short time, allows of the use of a lessened amount of oil. These two facts account, in part, for the widespread use of graphite. It is usually mixed with the oil directly in the crank case, or *splash part* of the oiling system, and should never be put into the lubricator. The reason for this is that the graphite seems to clog up not only the pipes leading to the bearings, but the moving parts of the pump as well. An excellent way to use it is to clean out the crank case and then, when putting

Fig. 42. Removing Oil Pump.

the oil back in or putting in fresh oil, use the graphite-oil mixture. To make this, add a teaspoonful of the purest, finest graphite obtainable to a quart of oil. This sounds like a very small quantity, but it is a fact that only a very small quantity is necessary. After mixing this very thoroughly (take plenty of time to mix it, as it is time well spent) pour it into the case. In actual running the graphite will reach the main bearings, which are the places where it does the most good, as it seems to give them a sort of thin, glazed coating, which acts to protect the pins. A smaller quantity of the oil with graphite in it should be used than of the ordinary clear oil. So, too, if the lubricator or pump is of such a construction that the graphite can be put into it with safety, the feeds can be reduced to about one-half of the amount usually used. That is, the addition of graphite to the oil allows of cutting the oil consumption in half, or, at least, of reducing very materially the amount of oil used.

CARBURETERS

Carbureter derangements form a very large part of the average autoist's troubles, although a very little study of the carbureter will convince anyone that it is a simple rather than a complicated part. Carbureters differ widely from one maker to another, in fact, from one maker's product this year to the same maker's output next year, but in the main, all work on the same principle. There is a fuel supply to a float chamber, the office of the float being to govern the level of the fuel and keep it constant. This it does through the medium of levers, weights, or other parts or combinations of parts, through its connection with the needle valve. The latter allows or prevents the inflow of the fuel, its position determining the amount flowing. From the fuel chamber, there is a connection to the vaporizing chamber, where the gasoline is sprayed into a column of air. The latter picks up the fine particles of the fuel, and vaporizes them. The resulting gas, a mixture of finely divided gasoline particles and air, is conducted into the cylinders by the suction of the pistons. There it is ignited and burns, with resulting expansion, which moves the pistons, and thus, produces power.

If any one of the parts or operations described—the float, float controlling mechanism, needle valve, jet opening, air supply, or suction from the cylinders—be hampered, reduced, or prevented from

working, the resulting mixture will vary according to the influence of the deranged or defective part or action upon the result. A rather common trouble is failure to start readily. One puzzled driver described his case as follows:

> The engine starts hard, necessitates priming, and the primer must be held down for a long time. When this is done, it will start and run for a short distance, when it will stop and the same proceeding must be repeated. On taking the carbureter apart, everything was clean and apparently all right.

If you are ever bothered in this way, you may be sure, granting that the spark is good, that the trouble lies in the fuel system. From the description of the trouble, it appears as if conditions were such as to starve the engine, although this was doubtless done unconsciously. This action is due to the fact that the gasoline level has been lowered so far that the suction of the engine does not draw up sufficient fuel for running. The fact that you have to prime to start and then prime to keep a going, even this priming failing to work sometimes, would seem to prove that the engine is not getting enough fuel. The trouble is that the spray nozzle has been raised too high, so that the gasoline level is four or five times as far below the nozzle as it should be. The engine suction must raise the gasoline this distance before any of the fuel will get into the cylinder, and if the distance exceeds the height to which the suction can raise the fuel, none will pass over. In a case of this sort, priming only helps temporarily.

Another somewhat similar trouble, with a not very different remedy is that of the engine ceasing to do its best work or "laying down" under a heavy load such as a stiff hill, deep sand, wet, sticky mud, or similar circumstances in which the maximum power is required. A driver bothered in this way described his trouble thus:

> Whenever I get in a heavy pull and open the throttle wide, the engine back-fires in the carbureter. It never does this on smooth road or when running under ordinary conditions, no matter how much I open the throttle. The trouble seemed to be worse on the magneto than on the batteries. New spark plugs and new batteries helped very little, nor did cleaning the carbureter.

This is apparently carbureter trouble, but the thorough cleaning and adjusting done there would seem to indicate that it is not at fault after all. About the only other solution is that the magneto is slightly out of time, say, to the extent of one tooth, on the driving gear. As the result of this, on slow speeds and even at high speeds

with but little load, the effect is not bad enough to be noticed. When working under a heavy load, however, even a slight error in the timing is greatly magnified. The same results might be caused by the valves being incorrectly timed, possibly, by the same small amount, *i. e.*, one tooth out of the way in the meshing of the driving gears. In case making the changes indicated above does not remedy the trouble, look at your inlet valve springs, or at anything else that could possibly cause the inlet to close late or slowly. Look at the valve seats to see if they are in good shape.

Another common trouble is that of wrong location of the jet nozzle, so that the fuel level as fixed by the float does not result in the proper flowing of fuel into the vaporizing chamber. Drivers who have trouble with this are frequently puzzled by it, because they

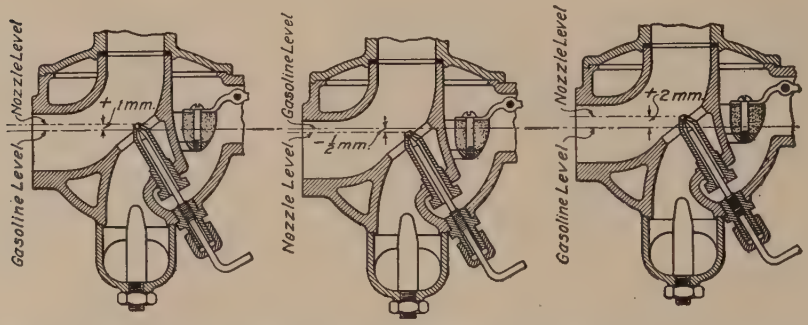


Fig. 43. Section of Carbureter Showing Variations of Nozzle Level. First Figure, Correct; Second, Too Low—Engine Will Flood; Third, Too High—Engine Will Starve.

assume that the carbureter is properly adjusted before leaving the factory. This is not always the case. One young driver said:

> What is the cause of this very puzzling knock? My four-cylinder engine develops a bad knock on a hill, which can only be eliminated by retarding the spark, but when that is done, the engine "dies," that is, gives no power. The effect is the same on level roads, when the throttle is opened more than one third. I may have deranged the level of the gasoline within the carbureter, while cleaning it. Would that have this result?

Now, this trouble is directly traceable to the change in the level of the nozzle made when cleaning, and made unconsciously. To quote from a plain statement of the effect of this change:

> By raising the spray nozzle, you lower the level of the gasoline relatively. Therefore, the liquid is less sensitive to the suction, which would reduce

the amount of gasoline used. At low speeds, there would be a tendency to *starve the engine which would be most noticeable on hills.*

The trouble is, that the spray nozzle has been lowered so that the engine does not get enough fuel at slow speeds and on hills. By raising this a small amount, Fig. 43, the engine will be able to suck up more fuel and the trouble ceases with the change. In making this change, be careful not to lower the nozzle too much at once, as the effect then is just as bad, the carbureter flooding at the slightest provocation. The better way is to lower the nozzle a very slight amount, say one-quarter of a millimeter, or perhaps one sixty-fourth inch would not be too much. Try this level out very thoroughly, and when you are satisfied that it is not right, alter the level once more. The experience that you will get during the process will be worth all the time taken up in the series of successive adjustments.

Taking the carbureter apart and cleaning it, then, should be done very carefully, until one becomes thoroughly familiar with it and with the influence which movement of the various parts will have. In Fig. 44, a foreign carbureter, partly taken down, shows how the top part of the float chamber should be removed in order not to damage the delicate needle point at the bottom of the float by which the latter governs the fuel supply. The cover should be loosened, and then lifted straight up, until clear of all remaining parts. With the cover off, the float may readily be removed in the same way, the only care being in starting it. As the amount or length of the needle point within the tapered seat is small, the float need be raised but a small amount to clear that. Then, it may be lifted out as one desires, since it usually is made from a half inch to an inch smaller in diameter than the chamber within which it works.

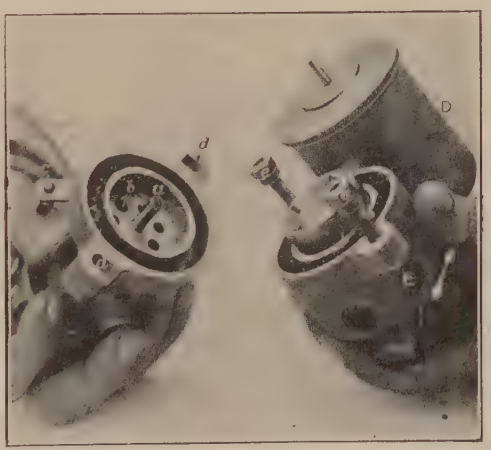


Fig. 44. Method of Dismantling a Carbureter.

The influence of the smallest things may be great as is shown by the following instance, which is illustrated in Fig. 45. A man having a small runabout with a rather large air vent in the gasoline tank, which latter was located directly over the engine, was bothered, in climbing hills, by too rich mixtures. These not only caused the engine to smoke badly, but caused a lack of power. On investigation, he found that the carbureter was located below and nearly underneath the gasoline tank. On a hill, the gasoline flowed out of the air vent, down the side of the tank, and dropped into the air intake thus increasing the mixture. Obviously the cure for this was to change the air intake so that the overflow from the tank could not drop into it, or any part of the carbureter. The sketch, Fig. 45, shows how he was advised to change it; the comment on the trouble and the proposed change were as follows:

The addition of fuel, as you describe, to the air at the air inlet will seriously disturb the running of the engine and probably give so rich a mixture as to choke the engine. It is advisable to remedy this at once, and the best way to do this is to prolong the present air inlet upwards and outwards away from the gasoline tank which causes the trouble. To do this, have a sort of stove pipe made of galvanized iron, tin, or any similar metal. It should be long enough so that its top is as high as the top of the offending tank, then make a big, easy bend away from the latter. The opening or mouth of the pipe should be so formed as to take a screen, which is necessary to keep out the dust, and should preferably be made removable, so that when the screen clogs with dust it can be taken off, cleaned, and replaced. For this purpose use a very fine brass gauze, which can be obtained at any hardware store, and for a small cost.

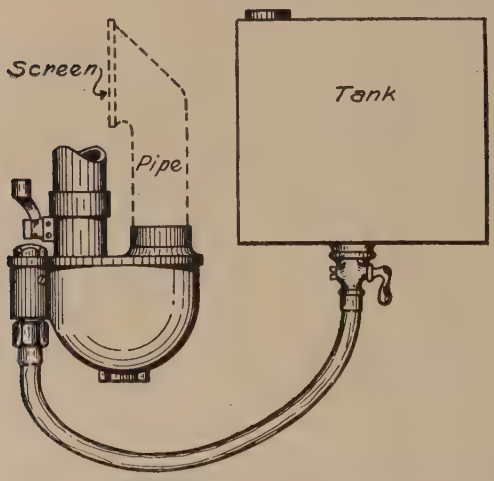


Fig. 45. Puzzling Carbureter Problem Solved.

BOB BURNAM, THE CROWNED "SPEED KING" OF THE WORLD IN HIS OHIO RACER

The Ohio Motor Car Company, Cincinnati, Ohio

IGNITION TROUBLES

There are a number of vexatious things to make the novice and prospective driver peevish. Chief among these is the trouble known as *misfiring*. This may be described as a failure of the mixture to fire in any one cylinder. It is usually due to ignition, so that the term as used, now means a failure to fire a charge due to an electrical cause. However, there are many common misfires which are due equally as much to a failure in the fuel supply system, so that the latter meaning attached to the word is somewhat of a misnomer.

Among the causes which contribute to misfiring may be mentioned ignition troubles, such as short-circuit in wires, exhausted battery, pitted or improperly adjusted vibrators of the coil, sooty or cracked plugs, loose connections or switch, dirty timer or commutator, punctured condenser, moisture in coil, wet wires or cables, water on distributing plate, dirt or wear on contacts in distributor, or dirt or wear in timer.

Then, there are the misfires due in part or wholly to the fuel or carburetion system. These may be grouped or listed as follows:

Carburetion and Fuel. Faulty mixture, sediment or water in the carbureter, clogged gasoline strainer, leaky float, clogged spraying nozzle, bent float-valve spindle, stale gasoline, partial stoppage of fuel supply pipe, hole or obstruction in intake pipe or manifold—these are not all the things that might happen, but are the principal ones which the writer's experience has suggested as most likely to occur to cars in general.

Foremost among the several difficulties which may be called *common* misfires, is the lack of a proper mixture. A rich mixture containing a relatively large proportion of gasoline in proportion to air is never desirable, inasmuch as it deposits considerable soot upon the piston, cylinder walls, and valves, and is, moreover, a waste of fuel. The motor will seldom run well on a very rich mixture, and the carbureter should be so adjusted that no more gasoline is fed to the mixing chamber than is sufficient for the motor to develop its full power. The exact mixture may be found by experiment.

A very rich mixture will cause misfiring; the motor will have a tendency to choke at other than high speeds, and is likely to overheat.

A lean or too thin mixture will, on the other hand, lower the efficiency of the motor, giving it a marked tendency to miss at high speeds, accompanied by a popping sound in the carbureter. In this case the needle valve should be adjusted to admit more gasoline, or if due to an excessive supply of air, the auxiliary air-valve should be adjusted to admit less air.

Bent Float Spindle. A bent float spindle will cause missing in one or more cylinders. The float spindle may become bent or it may become jammed into its seat by too vigorous priming. This may be discovered by unscrewing the cover and lifting out the float. Considerable care should be taken in straightening out a bent spindle, and the metal should be placed upon a block of hardwood, another block interposed, and the spindle gently tapped with a hammer.

Leaky Float. A leaking metal float or a fuel-logged cork will cause missing owing to its uncertain and erratic action. A cork float should be thoroughly dried out and then given a couple of coats of shellac to prevent it from absorbing the gasoline. As a new float is not at all expensive, the driver will probably find it more convenient to put in a new one. A metal float must be soldered when it leaks, and as the copper is thin and easily damaged, only a very little solder need be used. Precaution should be taken to keep the hot soldering bit away from the metal.

A clogged gasoline strainer is often the cause of trouble, and this is about the first thing that the autoist should examine when the misfiring is apparently in the fuel supply system. The brass gauze strainer should be frequently taken out and cleaned of any dirt that may have been filtered out of the gasoline.

Obstructed Spraying Nozzle. Owing to the small needle-like opening in the spraying jet, it is not uncommon for a particle of grit to lodge in the orifice and partially stop the flow of gasoline. The obstruction will not always interfere with starting, but as soon as the motor speeds up, the amount of gasoline sucked through the nozzle will not be sufficient for the motor at higher speeds, and it will soon begin to misfire until the motor slows down to first speed. A leak in the intake manifold will cause misfiring in one or two cylinders, and is often mistaken for ignition trouble. The cause may be due to loosening up of the bolts securing the flange to the cylinder.

Inlet Valve. The inlet valve is often the seat of the trouble, and missing here is generally caused by a weak or broken spring, a bent stem, or a carbonized valve. If the valve spring has lost its temper and broken down, the tension will be insufficient to properly hold the valve on its seat and the gas will partially escape and so cause missing. The insertion of an iron washer or two will increase the tension of the defective spring and serve as a temporary road repair. A broken spring may be similarly repaired by placing a washer between the broken ends. A bent valve stem should be taken out and carefully straightened by laying it upon a billet of wood with another block interposed between it and the hammer. Only a very little force is needed, and the stem should be repeatedly tried until it slides freely in its guide.

As was stated before, however, electrical troubles cause the greater part of misfires, and a simple explanation of the more common troubles of this kind will be of much service.

Troublesome Short Circuits. Either a partial or a considerable leakage of the electrical current may be due to worn or frayed insulation, and the bare wire may possibly come in contact with some metal part, and so form a short-circuit to the ground. This may or may not prove a constant short-circuit, as it sometimes happens that the vibration of the car will cause the bare wire to shift about, and the "short" will occur only now and then, as the wire brushes against the metal at intervals. Trouble of this kind is generally due to poor and old-time connections, and will but seldom occur with modern terminals. Perhaps the easiest and best way of correcting this trouble is to wrap a little tape around both the ends of the damaged cable and its binding post, which will keep the loose ends together and at the same time make certain of a good contact at the post.

Failures of the spark plugs due to defects in material and manufacture are not so common nowadays as in the past, but modern plugs are by no means immune from trouble. It is well to test the plugs if trouble is suspected. To do this it should be first ascertained which of the cylinders is misfiring by holding down all the vibrators of the coil but the one to be tested. This is inconvenient without assistance, but the vibrators may be cut out of action by simply inserting a bit of stout paper between the platinum contacts. When the missing cylinder is found, unscrew and examine its plug.

and if the points are clean and everything looks all right, connect up the high-tension wire, lay the plug on the cylinder, and turn the motor over until the proper contact is made. In case no spark is forthcoming and the plug is clean and to all appearances in good condition, it is very probable that the porcelain has developed a crack sufficient to form a leak and cause a troublesome and elusive "short."

However, this method of testing a plug is not infallible, since a minute crack in the insulation—not always visible to the eye—may not interfere with the production of a good spark in the air, but will cause leakage and so make a weak spark, or none at all, when called upon to overcome the greater resistance of the compressed gas. The electric current will always follow the path of least resistance, and as it is called upon to overcome considerable resistance in jumping between the two electrodes of the plug, it is obvious that a comparatively small defect in the insulation will prevent the production of a fat spark at the points.

Broken and Wet Wires. Broken and wet wires are occasionally the source of misfiring, and although little trouble may be anticipated from the well-made modern cables, the wiring of older cars—so largely seen in second-hand shops—is frequently defective. Where the wiring bears unmistakable evidence of having seen better days, the only satisfactory remedy is to put in new wiring throughout the car.

Wet wires are likewise the cause of considerable trouble in the older cars, as in many instances the high-tension cables are carried underneath the flooring and, being unprotected, are likely to get short-circuited through the water and mud splashed up by the wheels. In cases of this kind, it is desirable to re-wire the entire system when possible. In some cars, where this is not convenient, an old length of rubber hose may be pressed into service to enclose and partly protect the otherwise completely exposed wires.

Frequently, it is thought necessary to remove the magneto for examination or adjustment. This was formerly considered quite a task, but with the modern method of mounting, it is very readily effected. As Fig. 46 shows, most magnetos are now strap-held. To remove, then, it is only necessary to loosen the bolt or nut which holds the end of the strap, lift the latter off, and remove the magneto. This assumes that the various wire leads to the switch, cylinders, etc.,

have been first removed. In the figure, the nut has been removed, and the strap is being pulled aside. The other hand which is grasping the top of the magneto is then just ready to lift it out, as soon as the strap is out of the way.

Worn and Pitted Contact Points. The platinum contact points of the tremblers of the coil, if not properly attended to, will become rough and jagged and the poor contact will result in misfiring. The points should be examined occasionally, and, if uneven, they should be trimmed flat with a fine jeweler's or manicurist's file. The adjustment of the vibrator screw also plays an important part, and should be given its share of attention. A stiff tension is never necessary or desirable, as it will not only consume a greater amount of current, but will result in rapid wear and pitting of the contacts. The trembler should be adjusted with only sufficient tension to cause it to vibrate at a moderately high-pitched buzz. This adjustment by ear rests altogether with the experience and judgment of the driver, which may or may not be good.

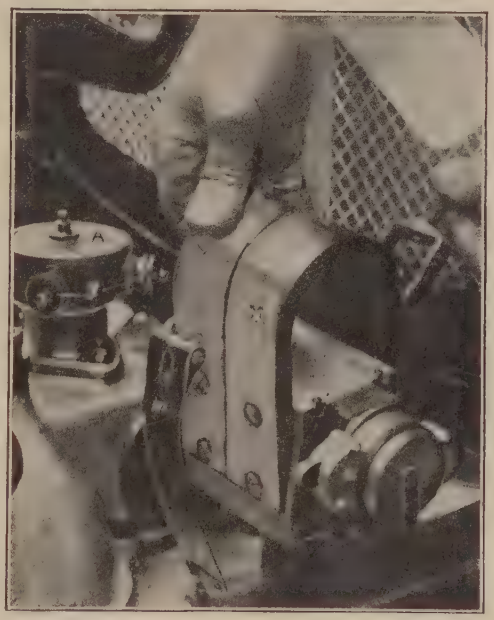


Fig. 46. Removing Magnets.

When the unit coil system is used—and this arrangement is now in general use—it is important, for the best coil service, that the vibrators of the several units be tuned as near alike as possible. This may be closely approximated by sound, but the only sure method is to measure the consumption of the current by means of a special ammeter. The exact amperage varies somewhat in different coils from $\frac{1}{2}$ to $\frac{3}{4}$ amperes—and to obtain maximum efficiency the maker's directions should be followed.

Exhausted Battery. A rundown battery is a very common source of misfiring, and although the symptoms are plainly apparent in troubles of this kind, the difficulty is not always traced to the proper cause. The fact that a weak battery will not generally prevent starting and only causes a misfire after the car is well under way, is, no doubt, the reason why the real trouble is not at once suspected. And again, the motor may run fairly well at medium speeds, but when the throttle is opened to admit more gas, the spark is too weak to fire the heavier charge and the motor commences to misfire, finally coming to a stop. In fact, when the battery fails to respond to the spark advance lever it may be taken as pretty good evidence that the voltage is too low, and that a new set of dry cells should be connected up, or the battery re-charged if of the accumulator type.

If the two sets of dry cells are used, they may be made to give some little additional service by connecting up in series—carbon to zinc. If two storage cells furnish the ignition current, connect them up in parallel—carbon to carbon and zinc to zinc. To avoid the annoyance of a weak battery, each dry cell should be occasionally tested for amperage and the defective cell renewed. A storage cell should be charged regularly once a month, and should never be allowed to become discharged.

Switches occasionally work loose, and, while an uncommon source of misfiring, it will occur now and then. A loose switch generally provides such poor contact that the motor will stop completely, but it may also cause missing in but one or two of the four cylinders.

The timer or commutator should be washed out thoroughly with gasoline at least once a week, to remove dust or other substances which will likely interfere with a perfect contact. If neglected, and dust and oil allowed to accumulate, the contacts will be imperfectly made and, the current being poorly distributed, misfiring will ensue.

Condenser and Short-Circuit in Coil. The condenser is not likely to cause trouble, and the most serious injury likely to befall this important part of the system is a puncture caused by the use of a battery generating a higher pressure (voltage) than the coil will stand. In this case the coil must be sent to the makers for repair. It occasionally happens, however, that misfiring results

from a broken connection to the condenser, or is due to the presence of dust or oil on the spring contacts. If trouble is suspected in the condenser, the contacts should be examined and cleaned with a bit of cloth wet with gasoline.

Water or Moisture in the Coil. Water or moisture in the coil will form a short-circuit and produce missing in the cylinder, and will rapidly exhaust the battery current. A primary or single wound coil—such as is used in low-tension make-and-break ignition—may be dried out, but the only way to fix up the high-tension coil is to send it to the manufacturers.

Magneto. In addition to those misfiring troubles which have just been mentioned, many of which are common to both magneto and battery systems, there are a few misfiring troubles which are confined to the magneto itself. Perhaps one of the most common causes of magneto misfiring is due to the interrupter-contact-arm roller becoming worn. A fiber roller will often wear unevenly, causing the cam to slip over the worn flat spot without making a good contact. In case of steel rollers and fiber cams, the latter will sooner or later show signs of wear.

Miscellaneous Troubles. The contact interrupter spring is also a common source of missing, as the spring loses its elasticity and becomes weak through constant use. Loose interrupter contacts are not quite so common, but will occasionally cause misfiring by working loose and so provide insufficient surface to insure a good contact.

Armature bearings work loose in course of time and cause misfiring by making too short a contact. Dust on the insulated face of the distributor is likewise conducive to missing, and the autoist should make it a point to keep this surface clean.

MEASURING INSTRUMENTS

A point worth more than passing mention is, that all ignition troubles may be detected at once by the use of common electrical measuring instruments. The two ordinary instruments are the *voltmeter* and the *ammeter*. The former measures the voltage or the pressure of the current, while the latter indicates the rate of flow or amperage of the current. Since both are necessary, they are combined in the modern instrument into a single unit, Fig. 47. When

mounted upon the dash board of the car, it is connected up as shown in the wiring diagram, Fig. 48. With this instrument in position and connected up, one may make a simple test at the slightest sign of trouble, and find out at once the source. Moreover, aside from making a test of this sort at will, it is possible to tabulate the common electrical troubles, their indications on the instruments, and their remedies. This makes a glance at the instruments, and another at the table, sufficient to start a person on the process correcting the trouble.

How to Proceed with the Test. In proceeding to make tests with the volt-ammeter, after having connected it up as indicated, the first thing to do is to make the distance between the spark-plug points as nearly uniform as possible, so that the width of the gap shall not exceed $\frac{3}{100}$ inch and then file the platinum points of the vibrators and contact screws so as to be sure that they are perfectly flat and true as well as smooth.

For this operation, a Nicholson XF Swiss file, about number 6 cut, should be used, because the ordinary fine-cut file is too coarse and cuts away too much metal. After filing the points, the contact screws of each unit should be screwed down until the vibrator has a play of about $\frac{1}{16}$ of an inch between the screw and the iron core.

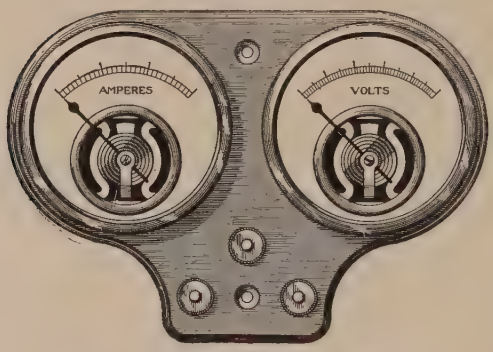


Fig. 47. Hoyt Volt-Ammeter.

Then, with the gasoline supply to the carbureter shut off and compression relief cocks open, turn the engine over until the timer makes contact and sparking takes place in one of the cylinders, any one being equally good.

Note the reading of the ammeter when the timer closes the primary circuit, and if the current consumption of the coil is greater than $\frac{8}{10}$ ampere, increase the vibrator gap by unscrewing the contact screw, and thus decrease the flow of current. Should the vibrator fail to act, however, screw down the contact screw and thus decrease the gap until the vibrator is brought into action. Proceed in the

same manner to adjust each of the vibrators until the current consumption of the coil units is equal throughout their number.

In making adjustments while the engine is at rest, the circuit being closed by the timer for a considerably longer interval of time than when in actual operation, it is necessary to set them for a current consumption about twice as great as is desired, because in actual operation the flow of current through the coils is intermittent, and the ammeter needle will stand at a point representing the mean current flow. For example, a two-unit coil adjusted to take $\frac{3}{4}$ ampere would show from $\frac{3}{8}$ to $\frac{1}{2}$ ampere on the ammeter, depending on whether the period of make or period of break is the longer.

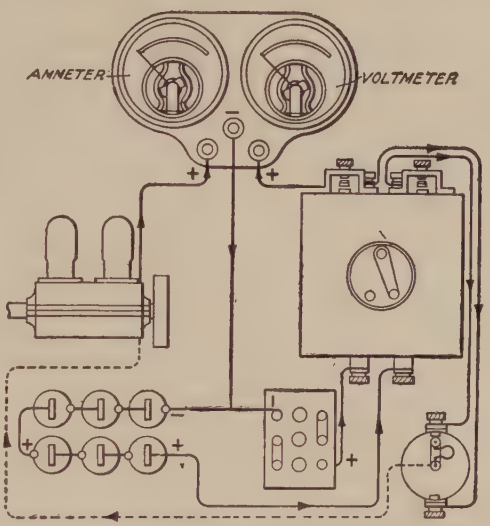


Fig. 48. Wiring Diagram for Volt-Ammeter Circuit.

Effect of Construction on Consumption. Since the construction of a coil affects the current consumption, and wide variations in the sparking efficiency of different makes arise from differences in usage as well as construction, no definite rules can be given for the exact point at which a coil vibrator should give best results. Generally speaking, however, it may be said that a coil adjusted to operate on less than $\frac{1}{10}$ ampere will give a thin, weak spark which would only fire a rich mixture. When adjusted to take more than $\frac{8}{10}$ ampere, trouble will be experienced from pitting and sticking of the platinum contact points and from rapid deterioration of the battery.

With the volt-ammeter in circuit, an observation of the normal rate of deterioration, after adjustments have been made, enables the operator to ascertain the relation between mileage and battery consumption. For instance, if a car will run 300 miles when the current consumption is such as to cause a pressure loss of $\frac{1}{2}$ volt, then the car

will run another 300 miles with a like drop in voltage, whether the battery is of the primary dry-cell or of the secondary storage type. Hence, a glance at the voltmeter will enable the operator to judge what mileage can be obtained from the battery before it is exhausted.

Whatever may be the cause of a change that affects the battery circuit, the voltmeter gives instantaneous indication thereof, the needle or pointer remaining steady only so long as conditions are normal. With a loose contact, the needle would oscillate back and forth; with a broken wire it would not move from zero; with a poor contact due to a corroded terminal, the reading would be lower than normal; and in case one or more cells should become short-circuited, the needle would drop to an extent depending on the scale value of the cells cut out. If the pointer does not remain steady on that point of the scale representing the voltage while the car is in operation, look for the trouble at once and remedy it.

What the Ammeter Reading Signifies. The operator having also familiarized himself with the significance of the ammeter indications, a glance at it shows whether there is a normal flow of current through the coil. Any departure from normal conditions, in fact, any change in the circuit that causes a variation in the quantity or volume of current flowing through the coil, is shown and can be accounted for by the behavior of the ammeter, whose indications serve as a reliable guide in locating ignition troubles. Poor contact is shown in a diminished current flow; too small a gap between the vibrator or spark points is indicated by an abnormally high reading; and a short circuit at the spark plug, due to soot or breakage, will cause the needle to be thrown to the extreme point of its movement. A loose connection causes oscillation, while a broken wire is indicated by stoppage of the engine and zero reading of the ammeter. A study of Table II will give some idea of the extent to which the volt-ammeter can be made of service in detecting ignition troubles.

SPRING REPAIRS

Due to the fact that spring makers the country over are now using better materials than before, spring breakages are few and far between. Time was when this was decidedly different, and a knowledge of spring repairs was very valuable, and even now, such knowledge is worth having. The usual spring breakage is a shearing off action

TABLE II

Common Ignition Troubles and Remedies

Reading of Voltmeter	Corresponding Ammeter Reading	Cause	Remedy
Steady.....	Regular .	Normal conditions.....	None necessary
Oscillating needle	Irregular	Loose contact in battery circuit—Leakage of secondary current — Short circuit or exhausted cells	Tighten connections—See that timer contact is made evenly—Eliminate leakage
Uniform or gradual drop	Regular.	Normal deterioration of battery	None required
Abnormal drop	High....	Rapid deterioration of battery because of short circuit at plug or in battery box—Improper adjustment of coil-vibrator or spark, plug gaps, latter being too narrow—One or two exhausted cells	Eliminate short circuit—Readjust vibrator and spark gaps—Replace exhausted cells
Normal....	Low....	Poor contact in timer, vibrator, or connections—Short circuiting of cells	Clean contacts, eliminating effects of corrosion or wear
Normal....	High....	Sooted spark plug—Gaps at vibrator or spark plug too small—Decreased coil efficiency	Clean spark plugs—Increase width of gaps—Readjust tension of vibrator spring
Normal....	Irregular	Poor timer contact.....	Fix timer
Normal....	Zero....	Broken ground wire.....	Put in new wire
Zero.....	Zero....	Broken wire between coil and battery or broken battery connections	Put in new wire

of the upper leaf. When this occurs, and the lower leaves are found to be still intact, it is possible to make a good serviceable repair with any stiff hard substance at hand, which may be fastened readily to the upper part of the spring. For fastening, the car may be raised with a jack, so as to take all weight off of the spring. Then, rope, wire, or any similar material may be bound around the two so as to fasten the broken spring firmly to the temporary stiffener. The weight may then be lowered onto it gradually. By proceeding cautiously, it is possible to get home with a repair of this sort, even when the repair part is but a piece of wood. This form of breakage and repair was so common at one time, and that not so very long ago,

that steel strips were made and sold for this particular purpose. In the illustration, Fig. 49, one of the steel bars *A* is shown, as well as its application to broken springs in several positions—*B* shows it applied to a spring broken in the center; *C* is a view of its application to one broken at the end, or at least, farther out than the preceding one; *D* shows its application to a spring with the whole end of the

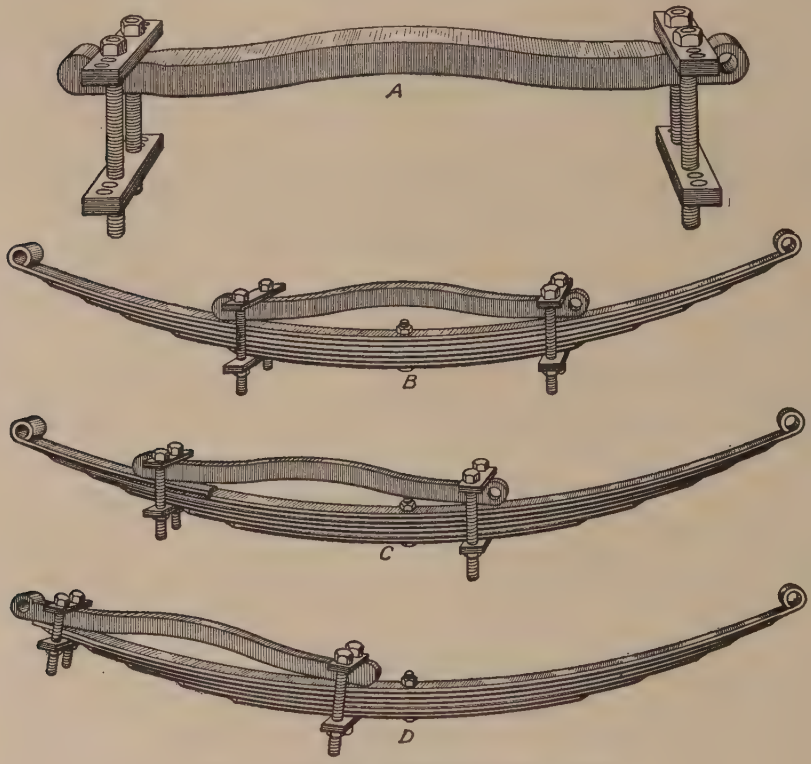


Fig. 49. Steel Bar Carried for Spring Repairs.

upper leaf broken off. In this position, the steel bar is bolted up the same as in the other cases, except that the end is allowed to project so that the drilled hole will come in a position corresponding to the former spring eye.

DEMOUNTABLE RIMS

Tire changing used to be the "bugaboo" of the lazy driver; but now, all that has been changed by the advent of the demountable rim, the demountable wheel, the quick change rim, and similar

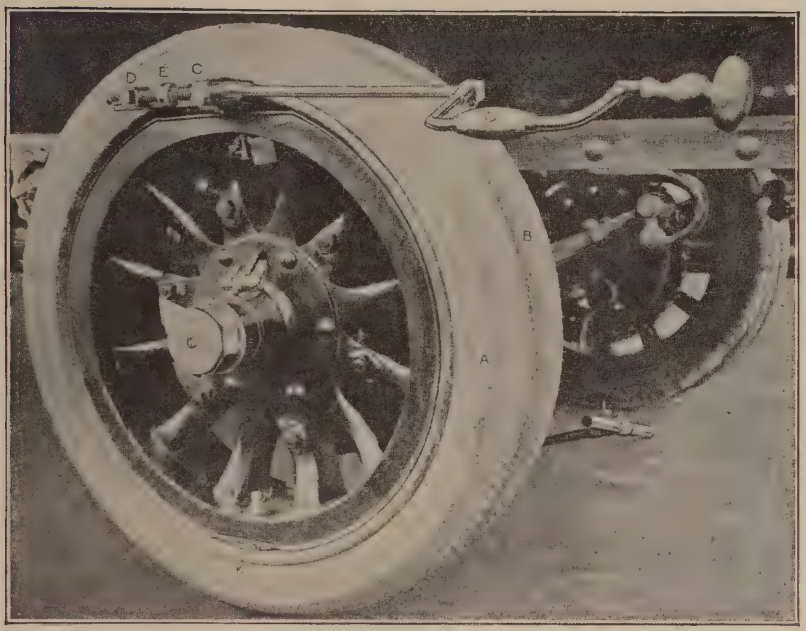


Fig. 50. Michelin Tires Showing Demounting Mechanism.

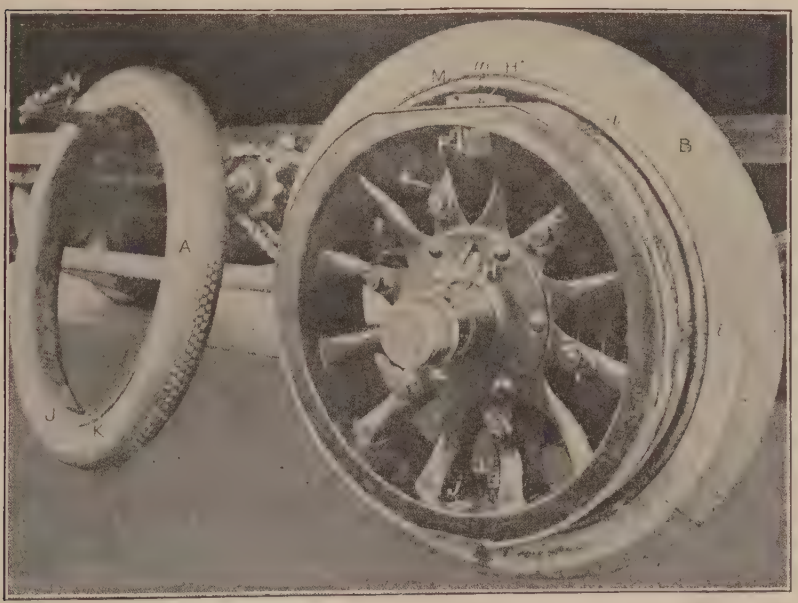


Fig. 51. Michelin Demountable with Outer Tire Removed.

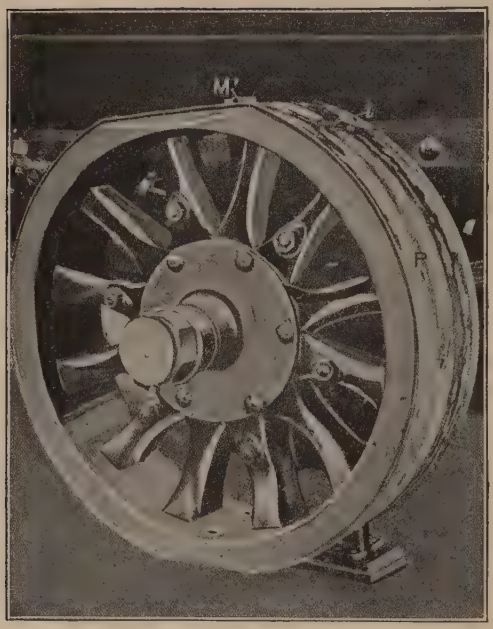


Fig. 52. Bus Wheel with Both Tires Removed.

devices. All of these administer to the comfort of the driver, in that they substitute for the spare shoe or external part of the tire formerly carried, another wheel or rim with a fully inflated tire all ready for use. The change, then, in case of a puncture or blowout, is a change of rims or wheels instead of shoes. The damaged tire is then carried home and repaired at leisure.

The designs of demountable rims are many and various, so much so that space prevents illustrating or describing half of them. The subject is so important, however, that a few selected at random will be described and illustrated. Thus, for track racing, where even *seconds* are precious, the Michelin Company has developed the demountable rim shown in Fig. 50, Fig. 51, and Fig. 52. The first shows the wheel in position, with tire in place, and the special bit and brace developed for doing the work of changing, also in place. A few quick turns of this, made in less time than it takes to tell it, and the tire is free to be taken off, sideways, as soon as the brace is taken out of the way. The illustration shows it in use on a bus fitted with double tires, and in Fig. 51, the outer tire has been removed. In Fig. 52, both tires

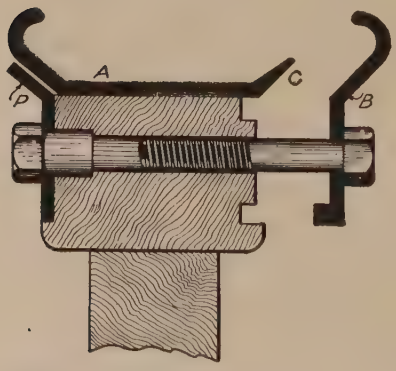


Fig. 53. Eclair Demountable Rim.

have been removed, and the wheel stands free and clear, showing its construction.

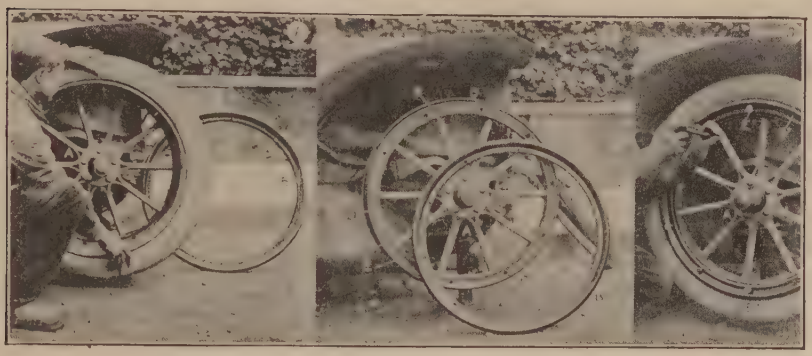


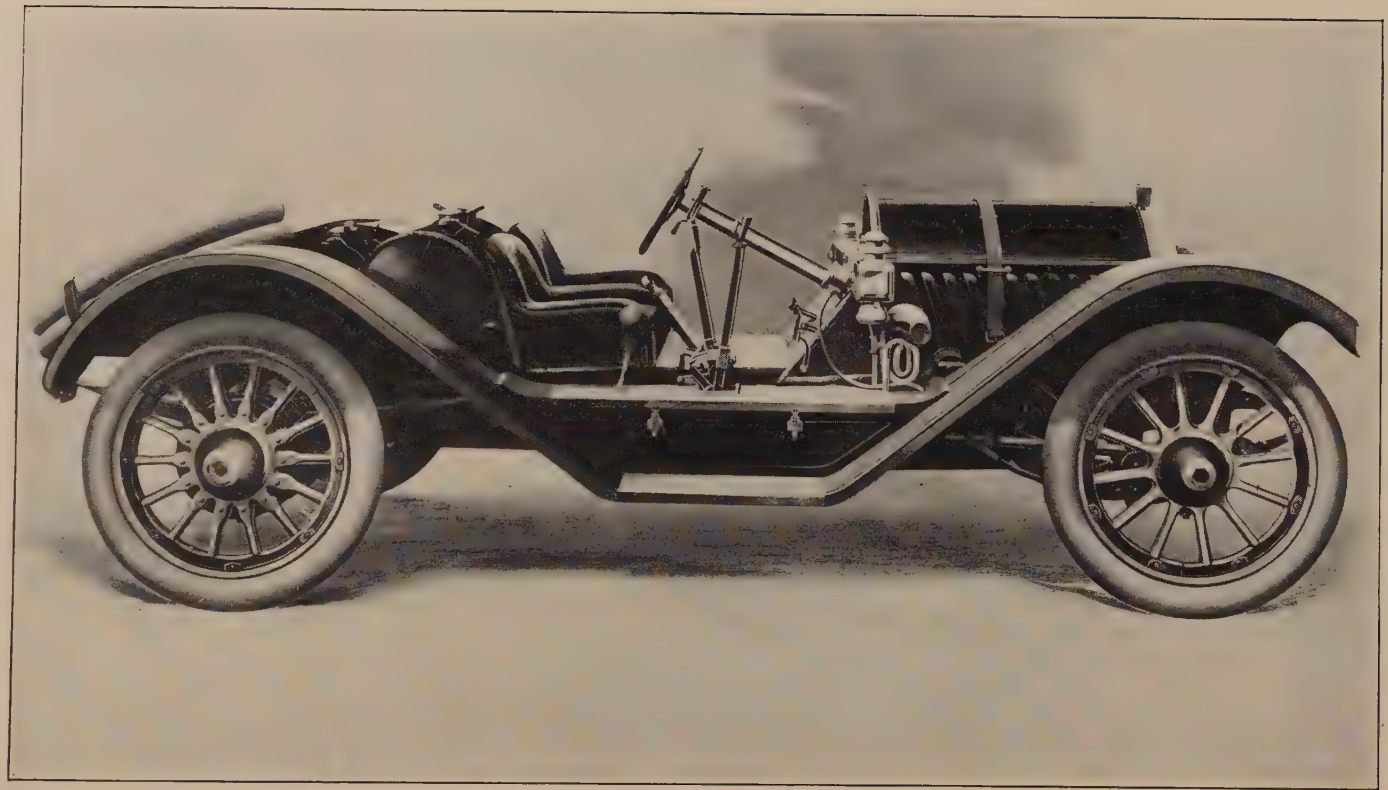
Fig. 54. Operations in Mounting an Eclair Rim.

In the wheel, or rather rim, Eclair, another French product, a special rim shape has been developed for this purpose and, in fact, this has been done with nearly all demountable rims. The shape in this case, as shown in the illustration, Fig. 53, is that of the ordinary clincher rim cut into two pieces, with a prolonged fla ge added to one of them in a vertical plane. This is for the purpose of holding the tire down to the rim, as it will be observed that the fixed part of the rim does not do so, except from its circular shape. The bolts are used to fasten the clamping rim on and to keep it from rotating. The left-hand part of the rim, marked *A*, carries the tire, and when the old tire and rim have been removed,

Fig. 55 A Dow Demountable—Loosen ing the Rim.

Fig. 56. A Dow Demountable—Removing the Tire.

Fig. 57. A Dow Demountable—Rim Removed.



OLDSMOBILE AUTOCRAT SPEEDSTER
Olds Motor Works, Lansing, Michigan

this, carrying a fully inflated new tire, is slipped into place. Then the locking rim *B* is slipped on, and through the medium of the bolts, ten in number, is pulled up tight, locking the first rim with the tire, tightly in place. The first picture, Fig. 54, shows a man slipping on the first part *A* with the tire, while beside the wheel is seen the locking ring *B*. In the last picture, he is shown tightening up the bolts with a special wrench for this purpose. The bit and brace are also used. In the central picture are to be seen all of the components. Special attention is called to a feature which would otherwise be missed. This is the rubber ring *D*, which is used to insure tightness, and an even pressure all around; it is placed next to the tire, and within the locking ring.

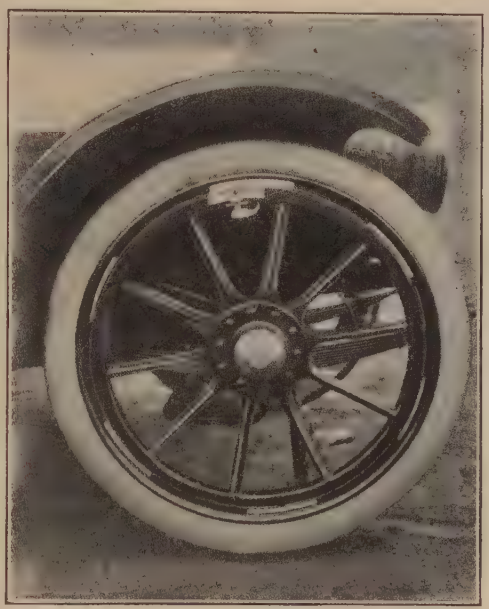


Fig. 58. A Dow Demountable Completely in Place.

In respect to demountable rims, the American does not have to admit any foreign superiority, for American demountables are just as good as those from the other side. One very good demountable rim is the Dow, made by the Dow Rim Company, New York City. This form utilizes the wedge as the basis of its locking device. The wheel felly carries on its outer circumference seven bronze plates which taper both laterally and circumferentially. The rim carries a similar set of plates of the same number and similarly placed. It also carries a rack, while the wheel carries a plate with a hole in it. A special tool for this wheel consists of a central axis with a small gear mounted upon it, and a cross bar to form a handle. When the end of this tool is placed in the hole in the felly, the gear will engage with the rack on the rim. Then by rotating the tool, the rim and with it the

tire, are also rotated upon the felly. This rotation in one direction tightens the rim on the felly and in the other direction loosens it, according as the wedges are forced up to one another or apart. The illustration, Fig. 55, shows the wheel jacked up off of the ground, and the driver just starting work upon it. A turn of the special wrench, and the wedges are freed. Then, as Fig. 56 illustrates, the driver grasps the tire firmly with both hands and pulls it outward and off. Fig. 57 pictures the rim and damaged tire completely removed; or it may be taken to represent the new tire which will be put back into the place of the damaged one. In that case, the operations are reversed, the wheel is slid into place, the wrench is applied, rim rotated until wedges lock, and the change has been completed in twenty seconds, leaving the wheel as it appears in Fig. 58.

SKIDDING

Not very long ago side slipping and skidding were supposed to be much the same thing, some people holding skidding to be a form of side slipping, and *vice versa*. Today, with a greater knowledge of both it appears that the two are entirely different as to causes, effects, and methods of prevention. Side slipping, which is much more simple and of considerably less importance, will be treated first.

Side Slipping. A car might exert sufficient traction over glossy ice to run very well as long as a straightforward path was followed, but as soon as a turn was made, the car would "side" in the direction of the former straight path. Of this slipping or sliding action, the rear wheels would do the greater part, the front ones acting as a pivot about which the rear end turned. Similarly in driving along a wet and slippery road surface, if a turn be made quickly, the inertia of motion of the rear end of the car will cause it to slide around the sharp corner. This is side slipping, as it is known in the automobile world.

Again, if the roadbed be narrow, as many country roads are, the wheels—either front or rear—might easily slip off of the crowned portion of the surface down to the side of the road. This might happen either on a road too highly crowned, or on a less highly cambered surface on which a light rain had fallen or which had been recently oiled. This, too, is called side slipping.

Not one of these sources of trouble is dangerous in the sense that it can not be controlled. It is never necessary to drive over slippery ice, and, when driving across wet and exceedingly slippery pavements or roads and around corners, one can always drive slowly and with great caution. The highly crowned or freshly-oiled roads can also always be avoided by traveling on other highways.

Theory of Skidding. The subject of skidding may not be so lightly dismissed for in it there are many things which can not be explained and, therefore, can not be avoided. The danger in skidding is due to the absolute lack of control on the part of the driver, particularly if the car has already started to skid. Where this action may lead a car no one can tell. During this "wild" period the car may run into or be run into by other cars, or may collide with obstacles along the roadside, thereby causing much damage. This almost always occurs upon wet or slippery pavements, and nearly always occurs in attempting to check the speed of the car while crossing such pavements or in attempting to make a sharp turn upon the same without checking the speed.

The actual action of skidding is something like this: The wheels, either front or rear, suddenly and without apparent cause start to swing around, generally taking such a direction as to follow a circle drawn with the other wheels as a center and the length of the wheelbase as a radius. This action is usually continued until a complete half circle has been covered. The traversing of this semicircle need not necessarily conclude the action, for cases are known in which a very violent skid resulted in a continuous uncontrollable swinging around and around, the car making several complete revolutions.

This latter action can best be compared to the motion of a couple dancing in which each revolution is accompanied by a forward motion. In the case of a car executing a very violent skid, the car swings around and around, either the rear wheels swinging with the front ones as a pivot, or the reverse, while at the same time the skidding machine executes a forward motion, generally in the direction in which the car was progressing before the skid started.

Causes of Skidding. *Power vs. Traction.* Skidding is induced or invited, when driving over wet or slippery surfaces: (1) When the clutch is thrown suddenly in or out, the engine being still running;

(2) when, with the power on, the brakes are suddenly applied; (3) when the steering gear is turned too sharply, with the power on and the clutch in. A close analysis of these cases will show that they may be interpreted from a lack of balance between the driving power and the useful force, that is, either the wheels revolve but do not progress or else they progress but do not revolve.

Thus, in the *first* case, if the clutch be out, let us consider the effect of suddenly dropping it in. The driving power of the engine is relatively great, but as the wheels have no traction on the slippery surface, this force can not be applied; there is, therefore, a lack of balance, and skidding occurs because of excess power from the engine.

Consider the alternate case, where the clutch, which is in, is suddenly withdrawn leaving the car moving forward under its own momentum. The engine here is useful, not as a source of power, but merely as a part of the comparatively heavy weight which is moving forward through its own inertia. A skid caused under these circumstances is the result of a lack of engine power, the excess here being on the side of traction, or progress, rather than revolution, as in the first case.

The *second* case, in which the brakes are applied with the engine power on, is seen to be closely analogous to the case of throwing out the clutch. Throwing on the brakes is about the same as cutting off the source of power, for in either case the forward motion is violently retarded. Here again, there is an excess of progress rather than of revolution, of traction instead of propelling power.

The *third* case is different from any of the preceding. With the power on, clutch in, and brakes off, giving the steering wheel a sharp twist in either direction starts a skid. The turning of the sharp angle reduces the traction, which is small at best, to a point at which it is not sufficient to propel the car forward. As the same power is available as heretofore to propel it forward, this is evidently another instance of an excess of power over traction, a superiority of revolution over progress.

It is a curious fact in this connection that slightly flattened or partly deflated tires will cause skidding to occur more easily than well inflated or hard tires. It would be natural to suppose that a slightly flattened tire, having more area of contact than the well inflated tire, would develop more of a drag or grip on the ground,

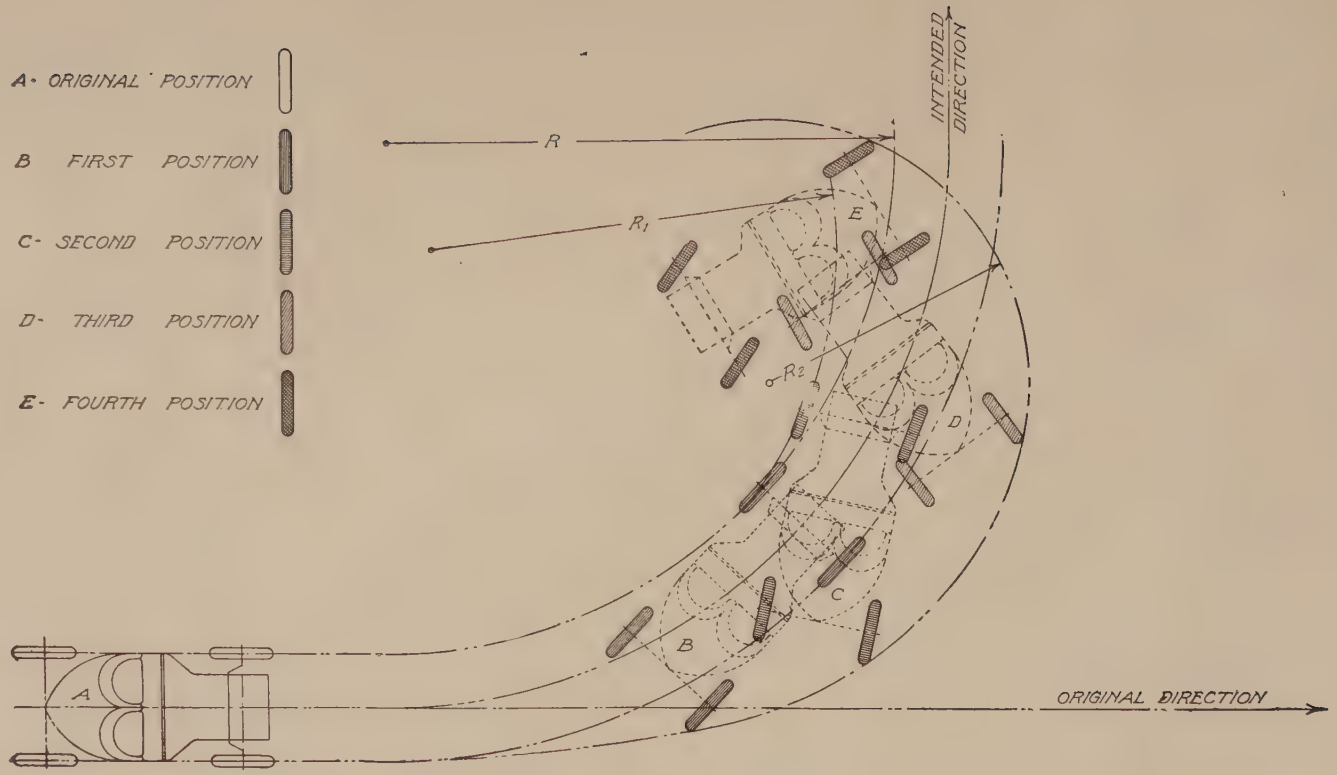


Fig. 59. Diagram Showing the Development of a Skid as a Car Rounds a Curve

thus tending to minimize the skidding action, but such does not appear to be the case.

Considering the case of a car going around a sharp turn, the momentum of the vehicle and the power of the engine combine to urge the car in the former direction, that is, along the tangent to the curve. The position of the front wheels, however, tends to guide the vehicle in a different direction, the engine giving some aid, according to the amount of traction. Should this traction be small, the tangential forces are much the larger and assume control of the situation, the side movement of the rear wheels becoming sufficient to nullify the action of the front wheels in rounding the curve, thus bringing them to a stop, and making them act somewhat as pivots for the rear wheels which continue their motion until the entire force is expended. The performance may be analyzed by the aid of Fig. 59, in which A is the original position of the car, which is about to make a turn of radius R. The car proceeds a short distance around this curve, to such position as B, when the superior impelling force of the rear end causes it to take a different course. This path is a curve whose radius rapidly decreases from the value R to, say, R_2, probably reaching nearly its limiting value which is the length of wheel base of the car. At the same time the front wheels are forced around in the arc of a circle of radius R_1, this being shorter than R but much longer than R_2. This action results in positions C and D. With the rear wheels following a constantly shortening radius while the front wheels are forced around in the arc of a circle which is shortening, it is true, but much more slowly than the circle of the rear wheels, it is obvious that the rear wheels will soon pass the front ones. This is actually shown in position E of the figure. This analysis should give as clear an idea of the process of skidding around a curve as could possibly be obtained from anything except a set of moving pictures, and these would be very difficult to obtain.

Miscellaneous Causes. Some of the causes of skidding have been discussed, but some further explanations may be of service. If the power applied to the rear wheels is not equally divided between the two wheels for any reason, the opportunities for skidding are greatly increased. This may be brought about by a tight bearing in one wheel, or a bearing which, by improper fitting, grips the wheel at one point but is loose at another; or the bearings on the differential

may grip one side of the differential case more tightly than the other, thus causing the differential to give more power to one wheel than the other.

Again, the design and construction of brakes may easily affect the behavior of the car. If these are not designed with an equalizer, or if fitted so that the equalizer can not work when the brakes are applied, more snubbing effort will be applied to one wheel than to another.

The loading of the chassis may increase or decrease the chance of skidding, for too heavy a load on the front wheels naturally means

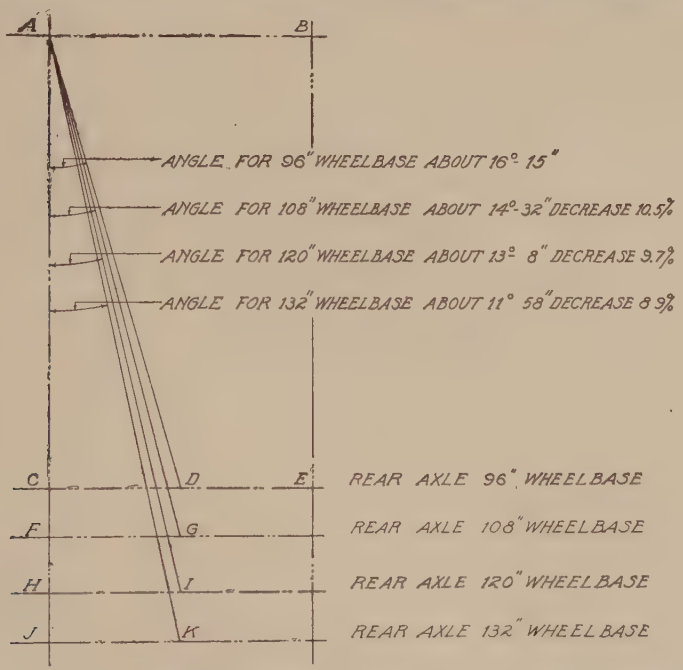


Fig. 60. Diagram Showing Determination of Skidding Angle for Different Wheel Bases

too light a weight on the rear end. It is a fact that cars thus constructed, especially when carrying no rear-seat passengers, skid very easily.

Methods of Prevention. *Long Wheel Base.* The length of the wheel base has an influence on skidding possibilities which may be analyzed by the aid of Fig. 60. Let AB represent the front axle, and CE the rear axle of the car. Marking the center D of the rear axle

and drawing two lines *AC* and *AD*, these two lines form an angle which might be termed the pivotal or skidding angle. When this angle is large, skidding occurs easily and often, and, therefore, anything which tends to reduce this angle, such as lengthening the wheel base, tends to reduce skidding. The distance *AC* represents a wheel base of 8 feet or 96 inches. If this be increased by 1 foot, *i. e.*, to 108 inches, the angle decreases from *CAD* to *FAG*. A simple calculation shows that the first angle is 16° 15′ while the second is 14° 32′, a decrease of 10.5 per cent. If the statement above is true, skidding should be reduced 10 per cent by lengthening the wheel base from 96 to 108 inches.

Similarly, *HI* shows the location of the rear axle for a 120-inch wheel base, causing a further decrease of 9.7 per cent, while *JK* shows the axle position when the wheel base is lengthened to 132 inches, a further decrease of 8.9 per cent. The decrease of the last over the first, amounts to 26.3 per cent.

Diagonal Braking. Diagonal braking, that is, braking one front and the opposite rear wheel, has been advocated as a cure for skidding. The same idea is conveyed in the present agitation of tire manufacturers for those persons who can not afford four new non-skid tread tires, as well as for those who do not believe in their efficacy, to try one on a front wheel and another on a diagonally opposite rear wheel. It is held that this combination gives perfect non-skidding qualities.

Miscellaneous Tire Devices. Non-skid tire treads, tire chains, rope grips, and similar devices are well-known and successful preventives. Practically every one of them works on the principle that since skidding is a side-slipping action, anything which prevents slipping either prevents skidding or reduces it to a minimum. The one fault with non-skid treads is that being rubber they wear smooth on ordinary roads, so that when wet weather comes the rubber-formed devices have worn so smooth as to be practically useless.

Metal devices, other than studded tire treads, must be put on the tires in wet weather, a task which is considered a good deal of bother by most persons; on the other hand, metal-studded tires, although always ready and very effective as skidding preventers, are somewhat noisy at all times. So, one might truthfully say that no perfect anti-skid device has yet been brought out.

Front-Wheel Brakes. Front-wheel brakes are the latest device offered for the purpose of preventing skidding and seem to give more promise than any of the others, being of such a nature as to be available in addition to the other devices. Front-wheel brakes add to the vehicle in other ways, too, and the practice of fitting them in place of, or in addition to, rear wheel brakes is growing rapidly. Beginning in England in 1910, some four or five manufacturers adopted them after more than a year's trial and test. One year ago, this list received important English additions, while at present front brakes are being taken up by one prominent Italian maker, two or three very prominent French manufacturers, and several more from Belgium and other countries.

These brakes are said to be equally as effective against rear or front skidding, although one might think from the location of the brakes that front skidding alone is prevented. The front brakes are applied first as strongly as possible, and then by following this with an application of the rear brakes, the car may be stopped anywhere and in a much shorter space of time than was possible with any former brake equipment. When this fact becomes better understood, front brakes will become universal on the better class of cars, despite the complications which they bring about.

Before going into the details of a number of front brakes, it will be well to call attention to the reason why this form of brake is more effective than the rear brake. In braking at the rear wheels, the greater portion of the load is in front of the wheels upon which the brakes act, resulting in the inertia of the heavy and bulky moving mass, producing a piling-up action on the front wheels. This action is in part responsible for skidding, in that a slight resistance on one side will cause the whole force to be directed to the other, with an ensuing front-wheel skid in that direction.

Now, if the front wheels be braked, the same piling-up action will result, but instead of being detrimental, it is advantageous, for it adds weight and effectiveness to the brakes, making them take hold better and thus stop the car quicker. The greater the weight or the greater the piling-up action the more effective they will become.

Again, the majority if not all of the stresses of skidding as well as of braking (whether skidding occurs or not) are taken by the tires, the rear tires receiving all of this and, in consequence, wearing out

much more quickly. Front-wheel brakes equalize this, for while with them the front tires take most of the braking stresses, the rears take all of the driving stresses, and neither one takes any side or skidding strains, thus increasing the life and efficiency of the tires.

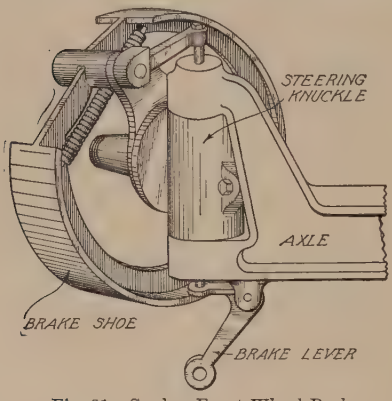


Fig. 61. Spyker Front-Wheel Brake

The one difficulty in the way of the universal adoption of front-wheel brakes, despite their prevention of skidding, is that the brake must turn with the wheel about the steering pivot or steering knuckle pin, and still be as applicable as when running straight ahead. This requirement is rendered as simple as possible, in the majority of cases, by passing the brake operating rods or levers through the center of the steering knuckle pin in a vertical direction, and in some cases, through the steering knuckle in a horizontal direction.

Fig. 61 shows the front-wheel brakes of the Spyker car, made in Holland. In this, the brake itself is of the internally expanded type and much like any other internal expanding brake, except for its operation. This is effected by a cam supported from the inner part of the wheel hub, and operated by a lever. This lever in turn receives its motion from a pin passing through the center of the vertical knuckle pin, which is worked from below by means of a bell crank and a cross lever placed underneath the axle, but not shown in this sketch. It might even be cable operated, as is the case with the Thames brakes shown at Fig. 62. These latter are hung on the hub of the wheel and thus made effective through the combination of cable operation and location on the hubs. This brake, too, is like any

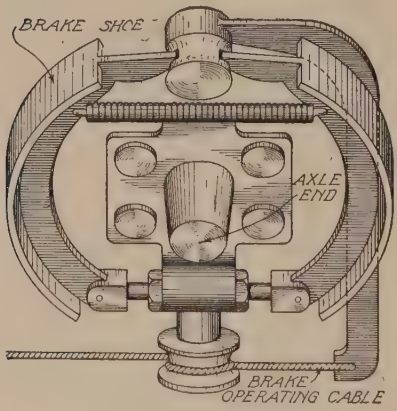


Fig. 62. Thames Front-Wheel Brake

other cam-expanded internal type of brake, the cable operation being the feature.

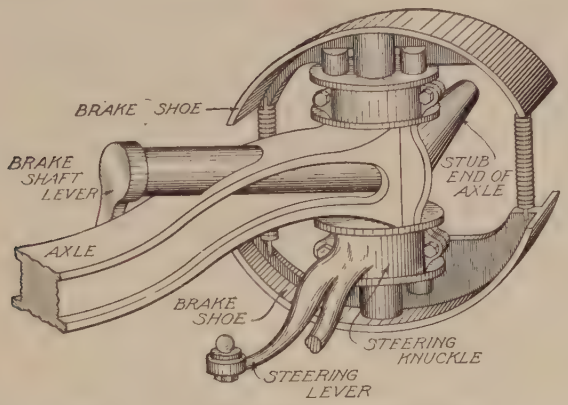


Fig. 63. Newton-Bennett Front-Wheel Brake

The Newton-Bennett brake, shown in Fig. 63, is on an English car, and has the brake shoes set horizontally instead of vertically.

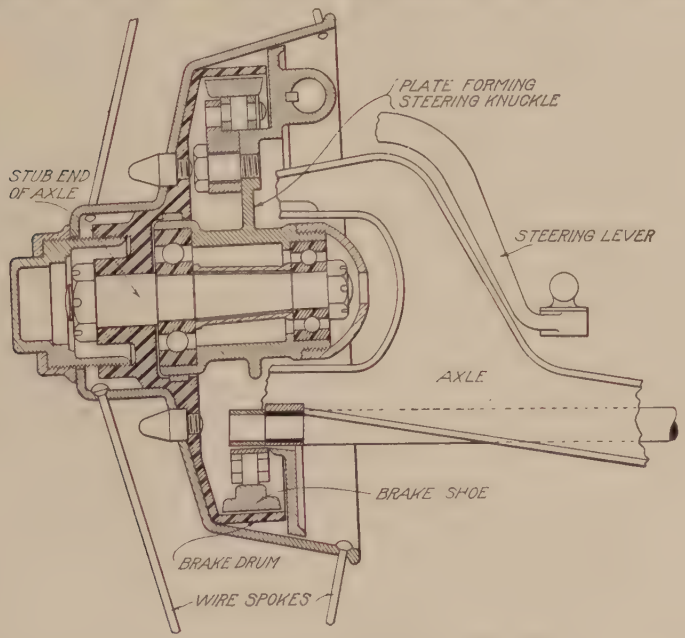


Fig. 64. Vertical Section of Crossley Front-Wheel Brake

A large boss on the axle forms the bearing for the operating shaft, which is actuated by means of a lever. Inside of the knuckle, at

the exact center of motion and rotation, this shaft terminates in a double cam, one half of which moves the upper shoe upward and the other forces the lower downward. These operating cams work on pins which pass through the center of the steering knuckle pin, so their action is not affected in any way by the turning of the wheels. The vertical springs joining the ends of the brake shoes, hold them normally away from the drums.

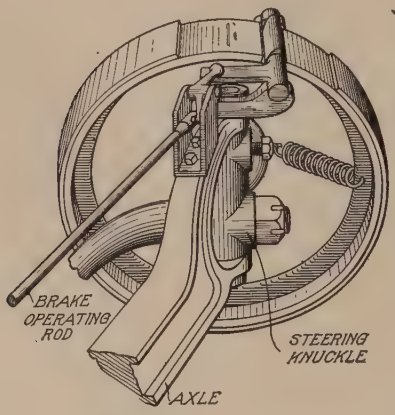


Fig. 65. Sheffield-Simplex Front-Wheel Brake

Unless the plane of the brake action and the plane of the wheel coincide, front braking will affect the steering action. In the Crossley (English) brakes shown in Fig. 64, this is cared for and the brakes are set well into the wheel, the plate forming the steering wheel being in the exact plane of the center of the wheel, while the brakes are situated in exactly the same plane. Thus, steering can have no effect upon braking nor braking upon the correct steering qualities.

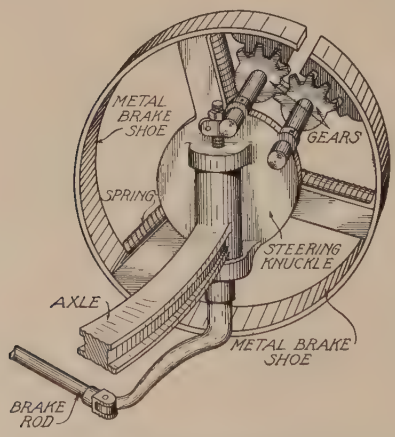


Fig. 66. Arrol-Johnston Front-Wheel Brake

This brake has a series of four brake shoes, cam operated from within, each one being removable for replacement. Circular motion of a cross rod beneath the axle operates a toggle, which forces a central pin upwards and works another toggle. Between the two toggles, the four shoes are moved around slightly and forced against the brake drums. This is a well-worked-out design.

A one piece shoe marks the Sheffield-Simplex (English) front brake, this being shown at Fig. 65. It is cam opened or spread from the top, this cam being worked through a lever, pivoted on the top of the steering knuckle and hav-

ing a number of universal joints in it to insure universal action. A special U-shaped support for this mechanism is built up on top of the knuckle. The operating rod runs across the car, as will be noted in the figure.

The Arrol-Johnston brake-operating means includes the use of gears, Fig. 66, not noticed in any other form. The brake band is in one piece with teeth formed in the upper or cut end with which mesh a pair of partial gears, one gear with each half of the band. A lever below the axle turns a vertical shaft passing through the center of the knuckle pin. On the upper end of this, a bearing carries the ends of the gear shafts, one of which is operated from the vertical shaft. This operates the other through the medium of the gear teeth.

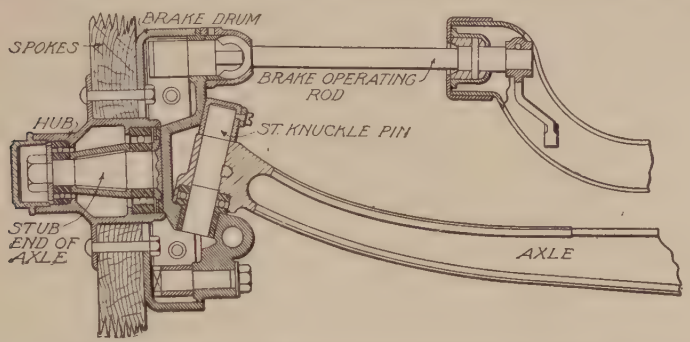


Fig. 67. Argyll Front-Wheel Brake Operating from Main Frame

Quite a different arrangement is in use on the Argyll, a Scotch car, Fig. 67. This brake is operated from the main frame, not from the axle as was the case with those previously described. To make this operation possible, the brake-operating shaft is fitted with a universal coupling at each end, thus allowing either vertical or horizontal movement or both. The sketch shows a sectional drawing through the wheel, axle, and brake, all of the parts being so clearly shown that further explanation would be superfluous.

All these forms have considerable mechanical complication, at least they add to the number of rods, levers, shafts, bearings for shafts, etc. To gain the many advantages of the front brakes without these counterbalancing disadvantages, a French engineer, Rolland, has brought out a front brake operated by hydraulic action. Its application to the Rolland-Pilain car is shown in Fig. 68. The usual form of brake drum is utilized, but the shoes are comparatively

small, and of full width. One of these works vertically upward while the other works downward. Each is moved by a piston between the two in the center of the steering knuckle pin, the movement being produced by a liquid forced in under pressure. In the illustration, the pipe for this liquid may be clearly seen entering the chamber in which the pistons are located. A pump driven from one of the engine shafts furnishes the force, this being thrown into action at will.

In short, the front brake has been unusually successful in actual practice, which is the only real test of any device. In view of this

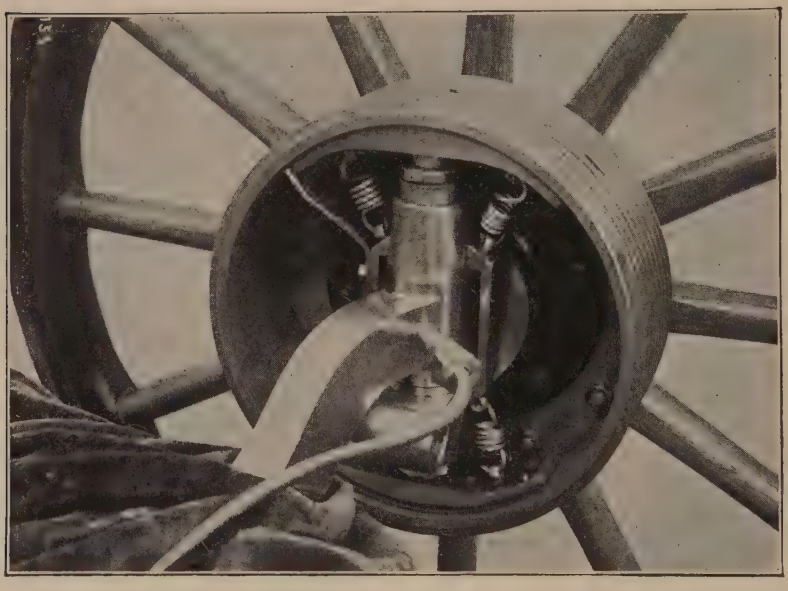


Fig. 68. Rolland Front-Wheel Brake within the Hub

success one may look for a much further future expansion in its use, for, as skidding becomes better understood, devices to prevent it will become more in demand, regardless of cost.

The same may be said of any other device which will stop or even limit or partially reduce skidding, including all forms of anti-skid or non-skid tire treads, tire chains, tire grips, longer wheel bases, narrower steering locks, better weight distribution, and, finally, more sense in driving, with the avowed object of avoiding the dreaded skidding and its consequent dangers.

SPEED-BOAT *SCRIPPS*, EQUIPPED WITH SIX-CYLINDER 50-60 H. P. SCRIPPS MOTOR

MOTOR BOATS

Introductory. The perfecting of the small gasoline engine has brought to the man of moderate means the possibility of enjoyment of a sport formerly indulged in only by the wealthy. A well-made, thoroughly seaworthy, and comfortable motor boat may be purchased for a much smaller sum than will buy an automobile of similar grade. This is quite evident, since, in the motor boat, we do not have the many mechanisms connected with the running gear of the automobile.

The success of the small gasoline engine in motor-boating has centered attention on this class of motive power for larger-powered classes of boats as well, until gasoline engines are largely supplanting steam engines on small pleasure excursion boats, and are also taking the place of naphtha launches in parks. The disadvantages of the steam-engine-driven small boat lie in the large space that has to be occupied by power plant and fuel, and in the dirt and smoke. In the case of the naphtha launch, the power plant occupies twice as much space as in the gasoline-driven launch, and moreover, the fuel employed is not so easily obtained as is gasoline.

The electrically-driven motor boat is used to some extent in parks and by private owners near cities where power is conveniently obtainable for the storage batteries. This type of motor boat, as well, has a promising field, though the power plant is more expensive for the same power than that for a gasoline-driven motor.

Classification. Motor boats may be divided into three classes, according to the shape of the stern, namely: standard or round or overhung stern, torpedo stern, compromise stern. The *round* or *overhung stern*, often designated as *standard stern*, gives a boat the greatest seaworthiness, but it is not adapted to high speed, since it drags a dead weight of many cubic feet of water. The *torpedo stern* is the fastest, but is not as seaworthy as the round or overhung stern. The so-called *compromise stern* is, as its name implies, a combination of the standard and torpedo sterns, the aim being to secure, by narrowing it, greater speed than may be obtained with the round

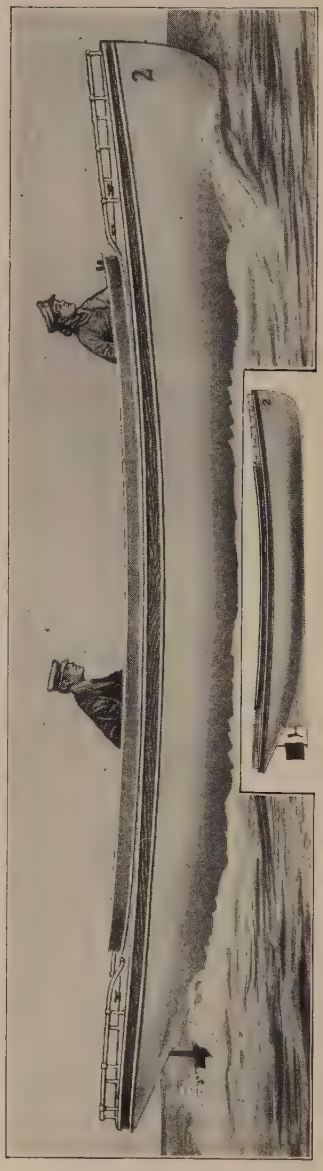


Fig. 1. Standard or Round Stern Motor Boat. *Brooks Mfg. Co.*

Fig. 2. Torpedo Stern Motor Boat. *Brooks Mfg. Co.*

stern, but also to retain a considerable degree of seaworthiness by using convex outlines instead of the sharp concave curves of the torpedo stern.

Fig. 3. 35-Foot Racing Boat with Torpedo Stern. *Racine Boat Mfg. Co.*

Fig. 1 shows a side view of the standard or round-stern type of motor boat. Fig. 2 shows an 18-foot torpedo-stern type built by

Fig. 4. Compromise-Stern Boat. *Pioneer Boat and Pattern Co.*

the same company as the foregoing one. Fig. 3 is a 35-foot racing boat with torpedo stern. Fig. 4 is a compromise-stern type.

A still further type is the tunnel or turbine boat, the only really satisfactory design for shallow waters. In this type, the propeller

Fig. 5. Tunnel Boat. *Racine Boat Mfg. Co.*

acts in a tunnel fore-and-aft amidships, at the stern. The preliminary revolutions of the propeller fill the tunnel with water, and

Fig. 6. Thirty-Five-Foot Passenger Tunnel Boat. *Truscott Boat Co.*

after the boat is started, the propeller has always a solid body of water to work in. This type of boat will run in less water than a

Fig. 7. Gasoline Cabin Cruiser, 65 ft. by 12 ft. 6 in. *Grand Rapids Gas Engine and Yacht Co.*

paddle-wheel boat of the same dimensions. Fig. 5 is a small tun-

Fig. 8. Deep-Water Cruiser. *Racine Boat Mfg. Co.*

nel or turbine boat. Fig. 6 shows a 35-foot passenger tunnel boat

Fig. 9. Freight and Passenger Motor Boat. *Wolverine Motor Works.*

with 8 feet of beam, making over nine miles an hour in fifteen

inches of water. Fig. 7 shows a cabined cruiser, 65 feet in length and 12 feet 6 inches in beam. This boat has accommodations for twelve passengers and a crew of four. The dummy stack is for ventilation of engine room and cooking galley.

Fig 10. Canoe Equipped with Motor, Rudder, and Propeller.

A deep-water cruiser is shown in Fig. 8. This large sea-going cruiser shows another modern type which is, to a considerable extent, supplanting the steam yacht. This type of boat is more economical to purchase and operate than a steam yacht, and affords at the same time greater accommodation. Another roomy type is

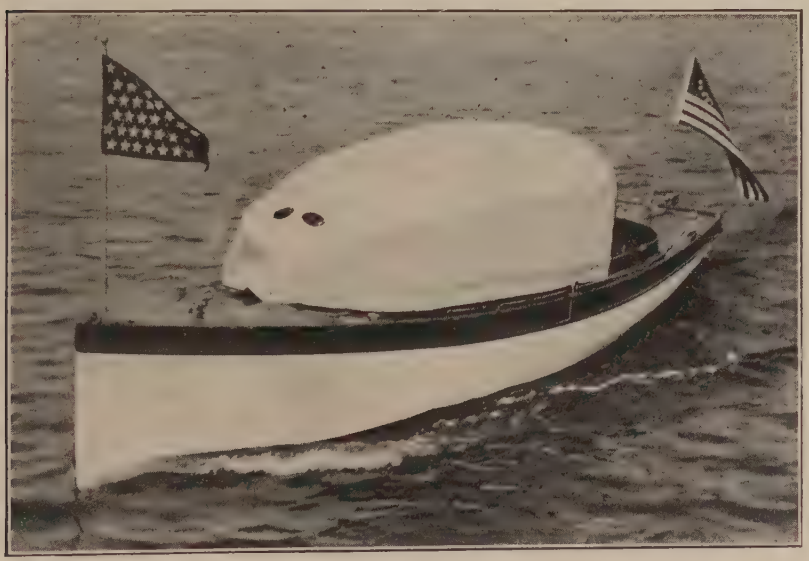


Fig. 11. Electrically-Driven U. S. War Dept. Cutter. *Electric Launch Co.*

the shallow-draft house-boat. One example of these motor boats is 50 feet long, draws but 16 inches of water, and makes a speed of 8 miles an hour. This type is in no sense a rough-weather boat, but

is intended primarily as a floating summer home. In it, all the conveniences and comforts of a summer cottage may be made available. It has two state-rooms, bath-room, living-room, galley, and spacious upper deck. Fig. 9 shows a motor passenger and freight boat operating between New Orleans and Port Eads, equipped with a 100-H. P. motor. The opposite extreme in the size of gasoline motor boats is illustrated in Fig. 10, which shows a small canoe equipped with motor, rudder, and propeller. This is perhaps the smallest and lightest form of gasoline-propelled boat.

Fig. 12. Twin-Screw Electric Cabin Yacht. *Electric Launch Co.*

Fig. 11 and Fig. 12 show electrically-driven motor boats. Fig. 11 shows a 28-foot electric cutter with spray hood up. This is one of a type built for the U. S. War Department. Bulkheads at each end of the boat form air-tight compartments so large that even if the cockpit were filled with water, the cutter could not sink. Metallic air tanks still further increase the buoyancy. Fig. 12 shows a 55-foot twin-screw electric cabin yacht capable of running 125 miles on one charge of the storage batteries.

Power for Motor Boats. As the two-cycle gasoline engine has its greatest field in marine service, it will be first considered. The four-stroke-cycle, or four-cycle, engine, has been far more generally manufactured than the two-stroke-cycle, or two-cycle, engine. It is generally conceded that for the low horse-powers required for small motor boats, the two-cycle type would offer a motor which would develop a given horse-power with considerably less weight and floor space than a four-cycle engine of the same power. This

is quite evident when one considers that a cylinder of a given size in the two-cycle type is twice as active in doing work as it is in the four-cycle type; that is, in the two-cycle type every other stroke is an explosive, or working, stroke, whereas in the four-cycle type every fourth stroke is a working stroke. It follows, of course, that in order to maintain the speed of rotation, the four-cycle type must have a much heavier fly-wheel for a given power than a two-cycle engine of the same power.

In the four-cycle type, the idle strokes give all parts a chance to cool off, and the behavior of the explosive mixture is for this reason more uniform than in two-cycle engines, where this cooling-off does not take place. However, in recent years, the two-cycle type has been bettered by many improvements in design, including provisions for greater water-jacket space. In the two-cycle engine, as the explosions occur twice as frequently as in the four-cycle, more jacket water is required; hence it will shut down quicker from a cutting-off of the water supply than will a four-cycle engine. In poorly designed two-cycle engines, trouble is experienced due to back-firing or explosions taking place in the crank case. This objection does not hold for well-designed two-cycle engines, of which there are now a number of types on the market.

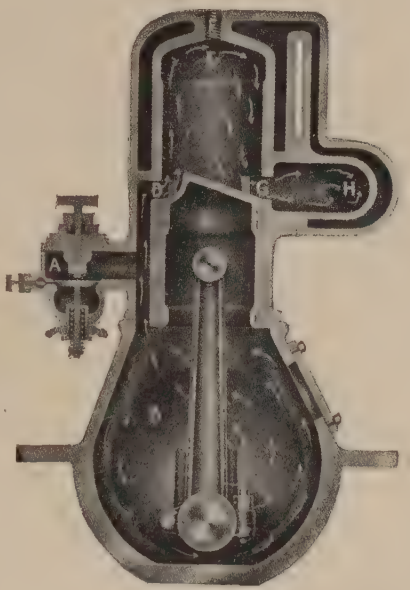


Fig. 13. Section of Two-Port Two-Cycle Marine Motor.

The Two-Stroke Cycle. Fig. 13 is a section of a two-cycle engine which shows the parts very clearly. The upward stroke of the piston *C* forms a suction in the base *B* which draws a charge of air and gasoline from the pipe *A* leading to the carbureter, into the base *B*. The in-rushing mixture strikes the warm wall of the cylinder before entering the base, thus insuring complete vaporizing of the gasoline. On the downward stroke of the piston *C* this mixture

is compressed to a pressure of 10 to 12 pounds per square inch. When the piston reaches the end of its downward stroke, it opens port *D*, allowing the compressed gas to pass into the cylinder. As the piston *C* moves up, it closes the port *D* and compresses the gases in chamber *E* to a pressure of 75 to 85 pounds per square inch. At the top of the stroke of piston *C* this compressed gas is ignited by a spark-plug which fits into the opening *F*. The force of the explosion pushes the piston downward. Just before the piston *C* reaches the end of the downward stroke it opens the port *G* allowing the dead gases to pass into the water-jacketed exhaust chamber *H* to which the exhaust pipe is connected. As soon as the dead gases are out of the cylinder, the port *D* is again opened and another charge is taken in. These operations are repeated at every revolution of the flywheel.

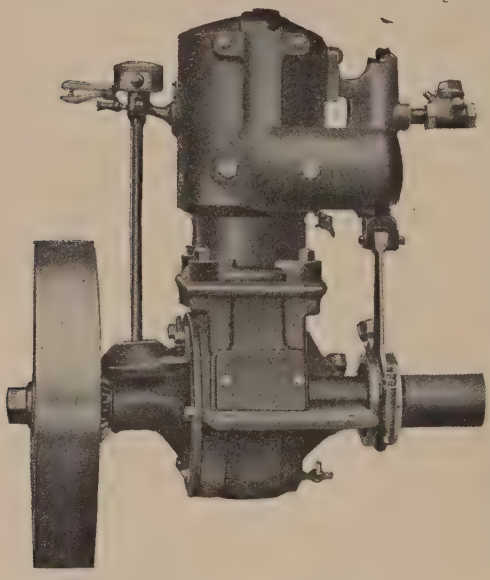


Fig. 14. Port-Side of Two-Cycle Marine Motor.
Caille Perfection Motor Co.

SUMMARY OF EVENTS IN TWO-STROKE CYCLE

DOWN STROKE

CYLINDER	CRANK CASE
Ignition in cylinder has taken place just before beginning of down stroke	Compression continues
Expansion	Compression in crank case begins
Exhaust	Port connecting to cylinder opens and pressure drops

UP STROKE

CYLINDER	CRANK CASE
Pressure in cylinder rises	Inlet valve is open and suction takes place into crank case
Ignition takes place at end of stroke	

Fig. 14 shows the port side, and Fig. 15 the starboard side of the engine shown in section in Fig. 13. It will be noticed that the water-

circulating pump is of the piston type, driven by an eccentric operated from the crank shaft. The timer or commutator is driven by bevel gears, one being located next to the flywheel, which may be seen in Fig. 15, the other being at the bottom of the vertical commutator shaft, and covered by the guard case.

Three-Port, Two-Cycle Engine. The engine above described is of the two-port, two-cycle type. In the three-port, two-cycle, a third port opened by the piston, is employed instead of an inlet valve. The third port is located below either of the two ports, and suction takes place into the crank case on the up-stroke of the piston, while this third port is uncovered. In other respects, the three-port, two-cycle engine is just the same as the two-port type. The advantage claimed for the three-port type is that it does away with the check valve required in the gas intake connection, or in the vaporizing valve, to prevent escape of gas from the crank case. The continual action of this check valve causes it to wear out rapidly, besides making a clicking noise. A float-feed carbureter can be used on the two-port type only in conjunction with a check valve. In the three-port type, no check valve is required, because the piston draws in the charge on the up stroke, and on the down stroke closes off the intake.

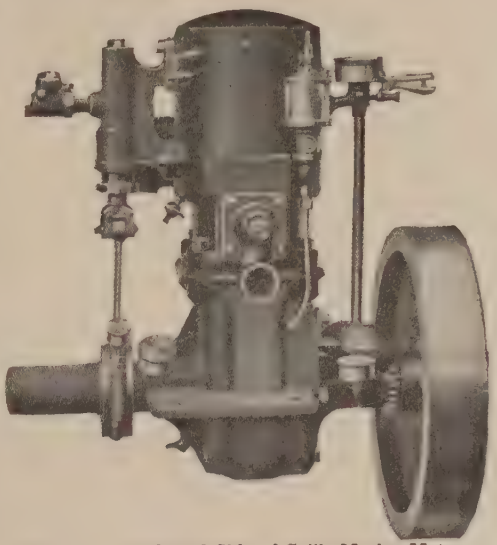


Fig. 15. Starboard Side of Caille Marine Motor.

Fig. 16 is an external view of the "Little Giant" marine motor. This is a three-port, two-cycle type. The carbureter is shown at the front toward the left. It is connected to the branch inlet pipe leading to the third port in each cylinder by a coupling and a cock. The engine shown is of the two-cylinder or "twin" type.

Relative Efficiencies of Four-Cycle and Two-Cycle Types. The principal loss in the two-cycle engine is that due to the necessity for

pre-compression of the charge in the crank case to a pressure of from 5 to 12 pounds per square inch above atmospheric pressure, so as to secure a quick transfer of the charge to the cylinder. This entire work of pre-compression is lost, so far as producing work is concerned, because its object is only to introduce the charge rapidly into the cylinder. On the other hand, the two-cycle motor does away with the cam shaft and poppet valves.

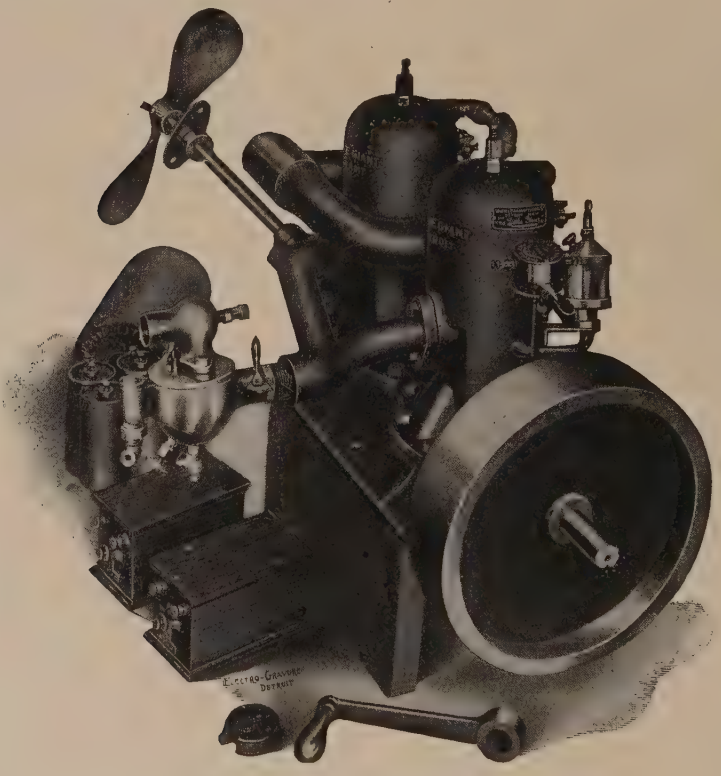


Fig. 16. Three-Port Two-Cycle Marine Motor. *United Mfg. Co.*

Professor Lucke gives the following table of average mechanical efficiencies of four-cycle and two-cycle engines:

Size of Engine	Efficiency (%)	
	Four-Cycle	Two-Cycle
Small, up to 25 H. P.	74–80	63–70
Medium, 25–500 H. P.	79–81	64–66
Large, 500 H. P. and over	81–86	63–70

According to the preceding tabulation, it would appear that the mechanical losses due to pre-compression are sufficient to exceed the gain by elimination of cam shaft and poppet valves. It is claimed,

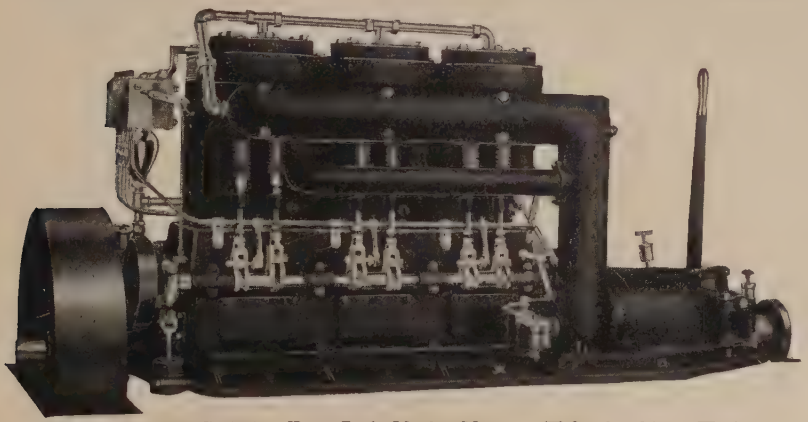


Fig. 17. Three-Cylinder, Four-Cycle Marine Motor. *Wolverine Motor Works.*

however, by several manufacturers of two-cycle engines, that their engines will not only give twice the power of a four-cycle engine of

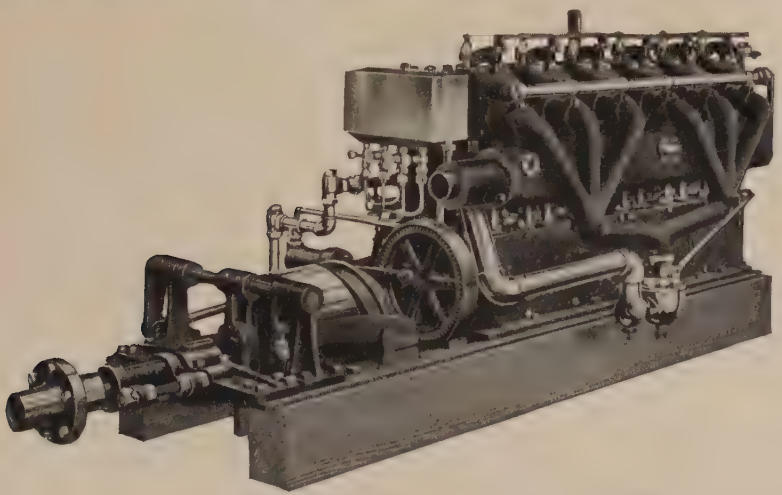


Fig. 18. Six-Cylinder Marine Motor. *Lamb Boat and Engine Co.*

the same size, but that they will give equal efficiency as determined by amount of fuel used per horse-power hour. It is certainly beyond question that great improvements have been made in two-cycle

gasoline engines in the last few years, and for small marine powers, there are more makes of two-cycle engines offered than of four-cycle engines. For heavy powers the two-cycle engine has been successfully applied, though in not as many instances as the four-cycle type.

Fig. 17 shows a three-cylinder, four-cycle, marine motor of 36 H. P. capacity. The cam shaft and valve springs are shown clearly, as is also the mechanically operated lubricating system. Fig.

Fig. 19. Vessel Using Motor Shown in Fig. 18.

18 shows a six-cylinder, 60-H. P., four-cycle engine. Fig. 19 shows the craft in which the motor illustrated in Fig. 18 is installed. Fig. 20 shows a four-cylinder, 60-H. P., four-cycle engine. Fig. 21 shows a 78-foot yacht equipped with two engines of the size and type shown in Fig. 20.

Reversing Gears. In the marine steam engine, reversal is accomplished by a Stevenson or other link movement, reversing the direction of rotation of the engine. In gasoline-driven motor boats, the engine rotates always in the same direction, and reversal is accomplished by means of a reverse clutch and gear system or by means of a reversing propeller.

The system of reversing clutch and gears usually employed consists of a conical disk clutch, fastened to the end of a stub shaft

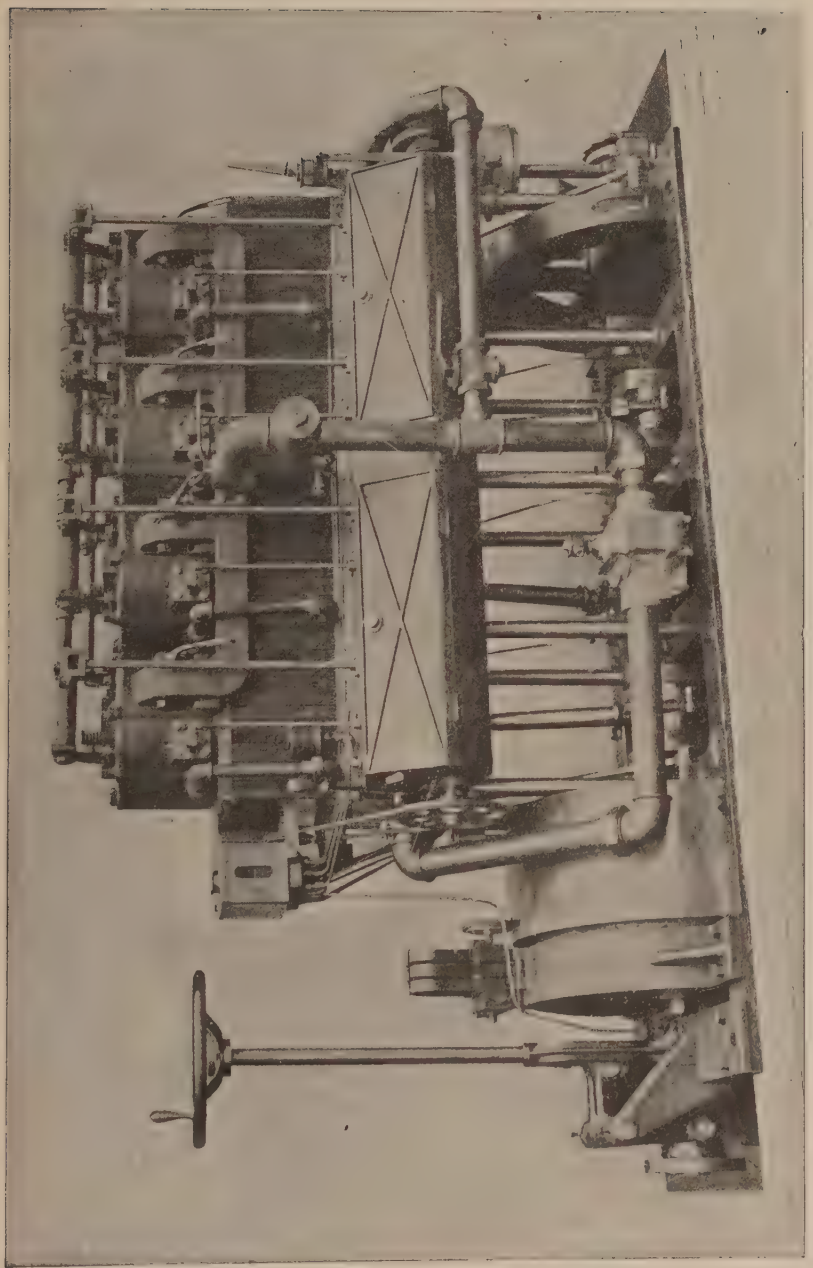


Fig. 20. Four-Cylinder, 60, H. P. Motor. *Murray and Tregurtha Co.*

Fig. 21. Seventy-Eight-Foot Yacht Equipped with Two 60-H. P., Four-Cylinder Motors. *Murray and Tregurtha Co.*

connecting the crank shaft with the propeller shaft. This shaft and clutch are capable of movement fore-and-aft by means of a hand lever. Fig. 22 is an external view of an assembled reversing gear as built by the Detroit Engine Works. The gears are enclosed in an oil-tight casing, so as to allow of liberal lubrication. The casing covers all moving parts and is so formed that there is no projection to catch on the clothing.

Fig. 22. External View of Reversing Clutch.
Detroit Engine Works.

Pulling the clutch lever towards the engine merely makes the clutch engage with the engine shaft; pulling it back disengages it, and the engine runs idle. Pulling the lever still farther back makes a gear on the stub shaft engage with internal gears fastened to a shell, keyed or bolted to the propeller shaft, thus producing reverse motion. Fig. 23 shows the reverse clutch, gears, and stub shaft used by the Lamb Boat and Engine Co.

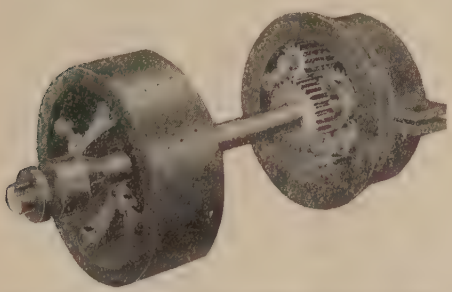


Fig. 23. Reverse Clutch Gears and Stub Shaft.
Lamb Boat and Engine Co.

Reversing Propellers. A boat equipped with a solid propeller requires several or all of the following operations for reversal: Adjustment of a throttle lever and spark lever for slower engine speed; throwing gear lever into intermediate position; throwing gear lever way aft; then advancing spark and opening throttle. With a reversing propeller but one motion is necessary, the engine running at the same speed all the time. The boat may be started, speeded up

slowed down, stopped, or reversed by the manipulation of but one lever.

Fig. 24 shows the Roper Safety Reversing Propeller and Fig. 25 shows its component parts. The propeller proper consists of a spider, four blades, a two-piece hub, and a locking screw. The spider is fastened by set screws on the shaft connecting to the motor,

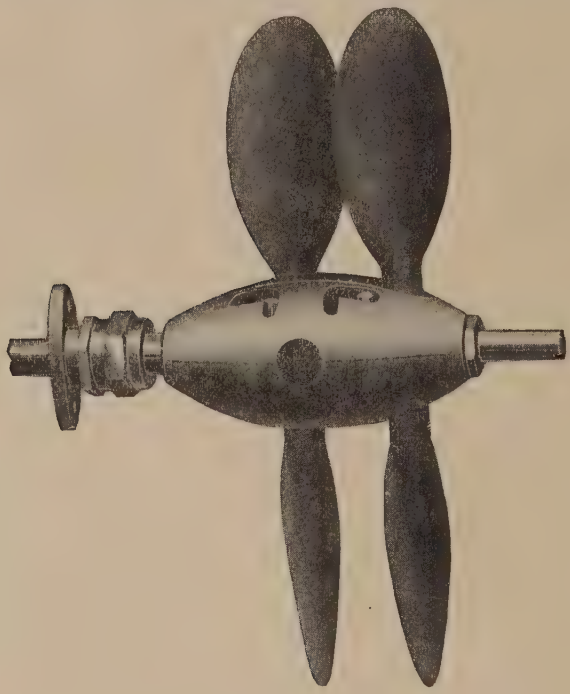


Fig. 24. Roper Reversing Propeller.

being fastened by a rigid shaft-coupling to the motor shaft. The spider is an *H*-shaped casting, the cross-bar of which is bored to receive the shaft, and the four projecting legs are turned and finished, and act as bearings for the blades to turn on. These bearings extend into the inside of the blades nearly to the center of pressure on them, thus preventing cramping. The surfaces of the blades follow the lines of a screw. The blades are provided with arms having lugs which work in cam slots in the hub or outer casing. The hub or casing is made in two sections which overlap at the ends and are joined together by a large screw passing through both parts. At

one end this screw is hollow, fitting snugly on the shaft, and at the other end the controlling sleeve is threaded, and forms the screw lock. By the motion of the sleeve and hub lengthwise of the shaft, the cam slots act on the blade arms to move the blades through the various positions corresponding to the different speeds of the boat.

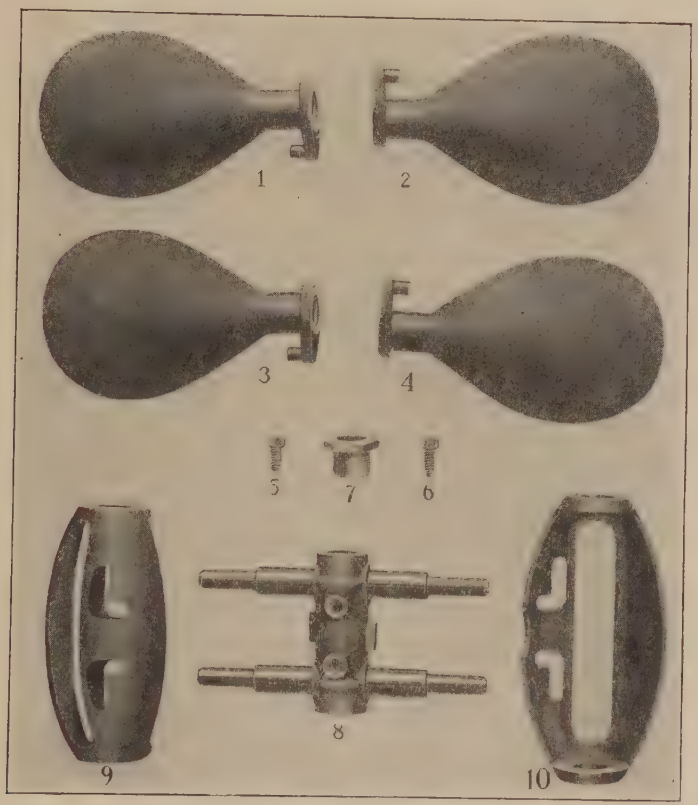


Fig. 25. Compound Parts of Roper Reversing Propeller.

When the blades are set for full forward speed, the sleeve and hub are in the extreme forward position. As they are moved backward by the controlling lever, the front pair of blades start to turn on their bearings toward a position in a plane at right angles to the shaft. This reduces the pitch of the blades and, consequently, the speed of the boat. Were this pair of blades the only pair, the motor would immediately speed up and begin to race as the pitch is reduced,

owing to the decreased resistance of the water on the blades. But the rear pair of blades have not yet been moved from their original position and are not moved until the other pair passes the position of least resistance. When the first pair of blades passes neutral position, tending to reverse the boat, the second pair begins to turn toward neutral position. When the reversing action of the first pair of blades becomes stronger than the propelling action of the second pair, the boat begins to run backward. Finally, both pairs reach reversing position and the same extreme pitch. This gives full reverse speed. Fig. 26 shows the operating lever and Fig. 27 shows various combinations of blade positions between full forward and full reverse.

Fig. 26. Operating Lever of Roper Reversing Propeller.

Control. In well-designed modern motor boats, engine control is effected as conveniently as in the automobile by means of levers and links which control the spark by shifting the position of the timer or commutator, and which regulate the amount of explosive charge admitted to the engine cylinders by opening or closing a throttling valve.

In addition to these devices, the steering wheel and reverse lever must be in convenient reach. Fig. 28 shows the controlling devices installed by the Lamb Boat and Engine Co. The small levers at the right of the steering wheel operate the throttling car-

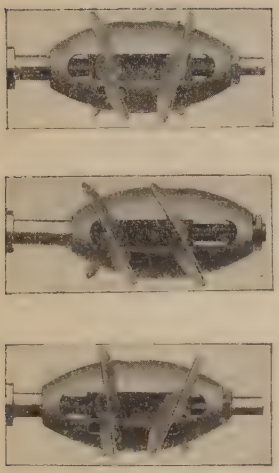


Fig. 27. Combinations of Blades of Roper Reversing Propeller.

bureter and the commutator. The speed of the motor may be instantly changed by moving these levers. The large lever at the left of the wheel is connected to the reverse clutch. This gives the steersman perfect and instant control of both motor and boat.

Pilot-House Control. It is a convenience to introduce pilot-house control or front-end control in some boats. This is accomplished by means of a steering column built similar to the steering column of an automobile. Fig. 29 shows pilot-house or deck control as installed by the Grand Rapids Engine and Yacht Co.

Solid Propeller. The solid or rigid propeller is fastened in a fixed position at the end of the propeller shaft. The shaft

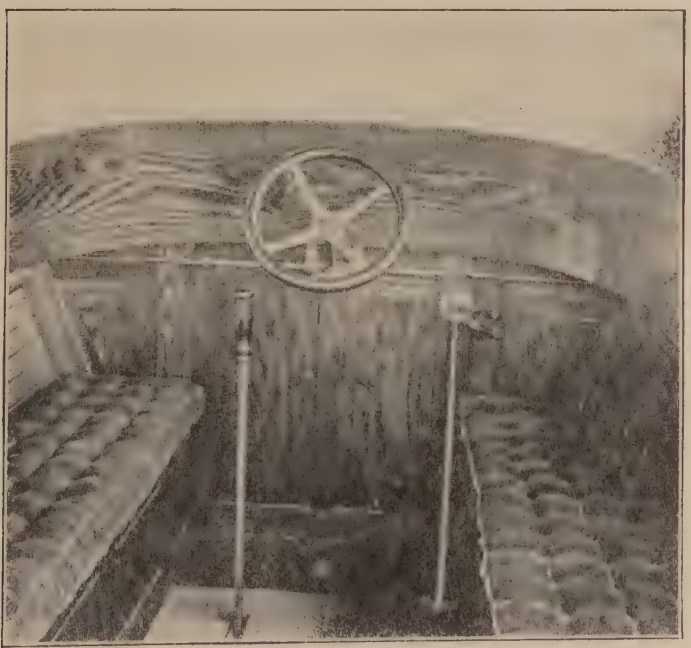


Fig. 28. Controlling Devices Installed in Boat. *Lamb Boat and Engine Co.*

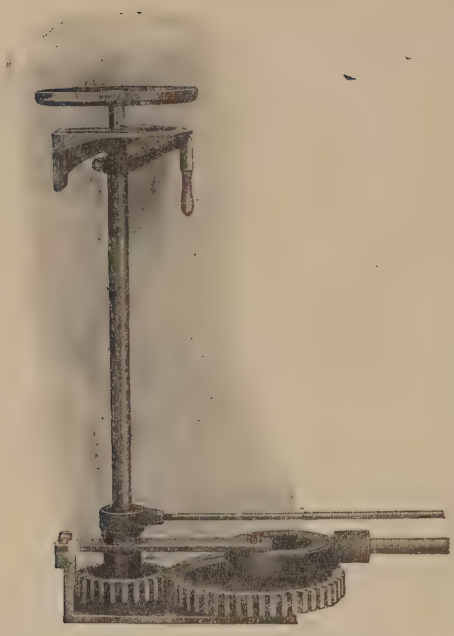


Fig. 29. Pilot-House or Deck Controlling Device.
Grand Rapids Gas Engine and Yacht Co.

passes through a sleeve and stuffing-box at the stern of the boat. A liberal bearing with thrust collars is provided for the propeller shaft at the stern. Fig. 30 shows a section of propeller, shaft, bearing, sleeve, and stuffing-box.

Thrust Bearings. The thrust of the propeller shaft ahead and astern must be taken up against the frame of the engine by means of some type of thrust bearing. The thrust bearing may be either a babbitted bearing or a ball bearing. Fig. 31 shows a babbitted ring thrust bearing. Fig. 32 shows a ball thrust bearing.

Mufflers. Some kind of muffler should be used with every marine engine. Muffling may be accomplished by means of some sound-deadening device and the exhaust gases then allowed to escape into the air, or better, the exhaust may be led under water, so as to minimize disagreeable odors. Underwater exhaust, if properly installed, need not cause any objectionable back pressure and consequent reduction of motor power.

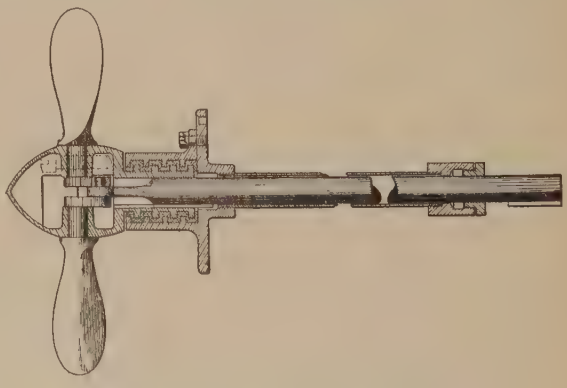


Fig. 30. Section of Propeller Bearing.

Fig. 31. Babbitted Ring Thrust Bearing. *Wolverine Motor Works.*

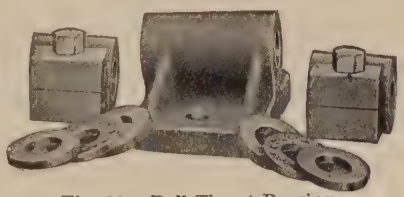


Fig. 32. Ball Thrust Bearing. *Dubrie Motor Co.*

Fig. 33 shows a water-cooled muffler. The exhaust gases discharge through a maintained water level one-half inch in depth, eliminating the noises without causing any back pressure. All circulation water is passed through the muffler, thereby absorbing the heat and condensing the gas.

Fig. 34 shows another plan for submerged exhaust. *A* is an expansion chamber, placed as near the engine cylinder as possible.

Fig. 33. Water-Cooled Muffler. *Grand Rapids Gas Engine and Yacht Co.*

B is the overflow water from the engine piped into the top of the chamber. *C* is the outlet to drain the water overboard above the water line. The exhaust pipe, which is in the stern of the boat, is at a height that will prevent water entering from the submerged exhaust. The exhaust outlet must not be more than two inches

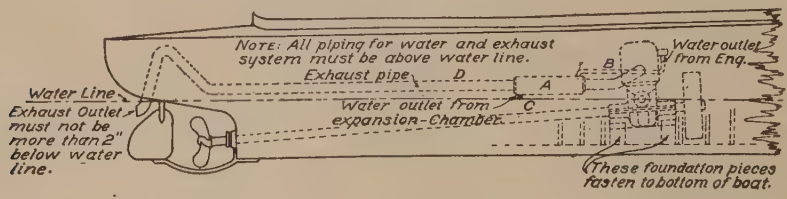

Note: All piping for water and exhaust system must be above water line.
Water outlet from Eng.
Exhaust pipe
D
B
A
C
Water Line
Exhaust Outlet must not be more than 2" below water line.
Water outlet from expansion-Chamber
These foundation pieces fasten to bottom of boat.

Fig. 34. Plan for Submerged Exhaust.

below the load water line. The stern is the best place for the exhaust outlet, because, when backing boat, or when the boat is standing at dock, the stern is naturally higher than when running ahead and this will prevent back pressure at the time of starting, or when backing up. It is very important that every part of the exhaust pipe, expansion chamber, and drain are placed above the water line, to prevent water from lodging in the exhaust system and causing trouble when starting the engine.

Where the boats have a fixed roof, the automobile type of muffler may be used. The exhaust pipe from the motor should be run to

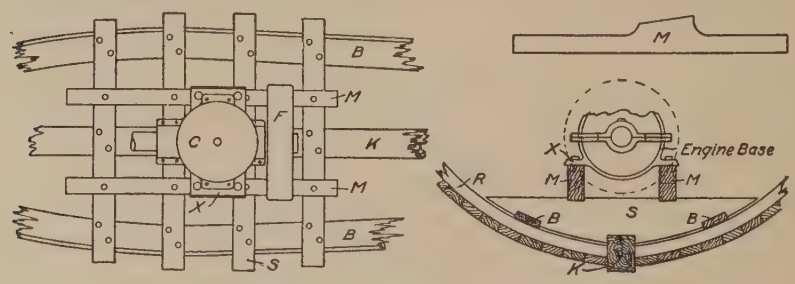


Fig. 35. Installation of Motor.

the roof, with a sheet-iron hood extending from the motor to and through the roof, and covered by a cone to shed water.

Installation. The motor should be securely fastened to a solid foundation by lag screws. The foundation should be of oak to give best results. The motor shaft must be in perfect alignment with

the propeller shaft so that there will be no binding when the boat is placed in the water. As the boat sometimes assumes a different position when in the water from what it had on the stocks, this

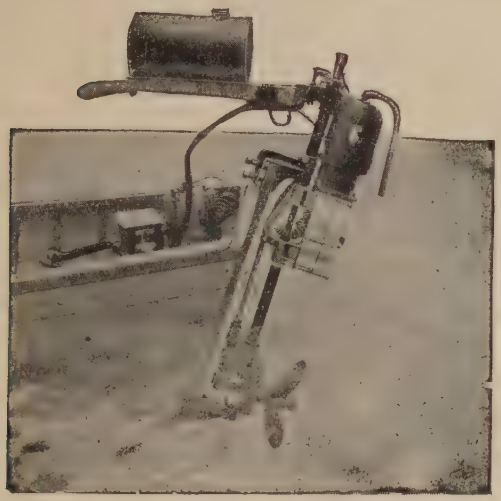


Fig. 36. Out-Board Motor Installation.
Waterman Marine Motor Co.

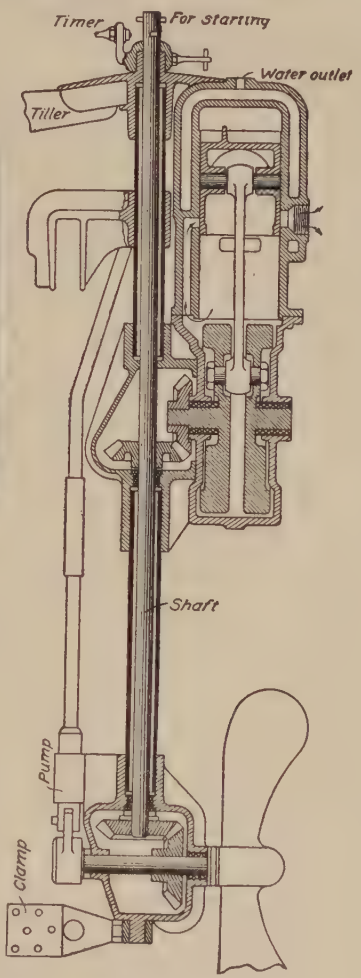


Fig. 37. Section of Porto Motor.

alignment should be looked to after launching, as a very little bind in the shaft interferes materially with successful running.

To get the line of the propeller shaft, set a stick across the hole in the shaft log on the outside of the boat. Tie a piece of string to the stick and run it up through the shaft log to the bow of the boat. The sills *M*, Fig. 35, should be cut so that the slanting edge is parallel with the line of the string, and at just a sufficient amount below to make the center of the engine shaft coincide with the string. Place the stuffing-box on the outside of the boat with a piece of rubber packing between it and the wood, and draw it tight with the lag bolts. Set the shaft in place and put the engine on blocking. Raise the engine up with flat pieces of white pine until the engine shaft is $\frac{1}{8}$ inch

higher than the propeller shaft. Drill holes part way into the sills so the lag screws can be started into the oak easily. Draw the lag screws down tight and connect up the shaft. Be sure that the engine is square with the shaft, and that the shaft does not bind anywhere. Fig. 35 shows the installation plan as used by one marine motor company. *K* is the keel, *BB* are the bilge stringers, *C* is the engine cylinder, *XX* are the engine flanges, *F* is the flywheel, *MM* are engine sills, *SS* are the cross floors, and *RR* are the ribs.

Shaft Hole. The shaft hole should be drilled at such an angle that it is in line with the propeller shaft, and so that the propeller will be entirely submerged, and further, so that no part of the motor bed or flywheel will come in contact with or touch the inside of the boat, other than the foundation timbers.

Gasoline Tank. The gasoline tank should be placed as high up in the bow of the boat as possible, so that the gasoline will have sufficient head to flow to the carbureter with a good strong force.

Out-Board Installation. This is a system for attaching a gas-engine motor quickly and cheaply to any small boat without previous preparation of the boat. It can be as quickly and easily removed and packed away without damage to the boat. It can also be used on sailing vessels as an auxiliary. Fig. 36 and Fig. 37 show views of the Porto out-board system.

Electric Motor Boats. The electrically-driven motor boat is considerably more expensive for a given power than the gasoline-driven boat, but it possesses certain features which make it desirable in many instances. There is no noise and perfect freedom from odors; no inflammable fuel needs to be carried. The instructions as to electrically-driven automobiles and care of storage batteries apply equally well to electrically-driven motor boats.

U. S. RULES* OF NAVIGATION

Whistle—RULE I. When steamers are approaching each other "head-and-head," or nearly so, it shall be the duty of each steamer to pass to the right, *i. e.*, port side of the other; and the pilot of either steamer may be first in determining to pursue this course, and thereupon shall give, as a signal of his intention, one short and

*These rules do not apply to gasoline launches, but are given here for the convenience of launch owners.

distinct blast of his steam whistle, which the pilot of the other steamer shall answer promptly by a similar blast of his steam whistle, and thereupon such steamers shall pass to the right, or port side of each other.

Fig. 38. "Head-and-Head" Approach.

But if the course of such steamers is so far on the seaboard of each other as not to be considered by pilots as meeting "head-and-head," or nearly so, the pilot so first deciding shall immediately give two short and distinct blasts of his steam whistle, which the pilot of the other steamer shall answer promptly by two similar blasts of his steam whistle, and they shall pass to the left, *i. e.*, on the starboard side of each other.

In the night, steamers will be considered as meeting "head-and-head," so long as both the colored lights of each are in view of the other.

Fig. 39. Passing to Starboard.

RULE II. When steamers are approaching each other in an oblique direction, as shown in Fig. 41, they shall pass to the right of each other, as if meeting "head-and-head," or nearly so, and the signals by whistle shall be given and answered promptly, as specified, Rule I.

RULE III. When steamers are running in the same direction, and the pilot of the steamer which is astern shall desire to pass on the right or starboard-hand of the steamer ahead, he shall give one short blast of the steam whistle as a signal of such desire and intention, and shall put his helm to port; and the pilot of the steamer ahead shall answer by the same signal, or, if he prefers to keep on his course he shall give two short and distinct blasts of the steam whistle, and the boat wishing to pass must govern herself accordingly, but the boat ahead shall in no case attempt to cross her bow or crowd upon her course.

Fig. 40. Passing to Port.

All vessels must have a green light on the starboard side and a red light on the port side.

First Situation. (Fig. 38.) Here the two-colored lights, visible to each, will indicate their direct approach ("head-and-head") toward each other. In this situation it is a standing rule that both shall put their helms to port and pass to the right, each having previously given one blast of the steam whistle.

Fig. 41. Oblique Approach.

Second Situation. (Fig. 39.) Here the green light only, will be visible to each, the screens preventing the red light from being seen. The boats are, therefore, passing to starboard, which is rulable in this situation, each pilot having previously signified his intention by two blasts of the steam whistle.

Third Situation. (Fig. 40.) *A* and *B* will see each other's red light only, the screens preventing the green lights from being seen. Both vessels are evidently passing to port, which is rulable in this situation, each pilot having previously signified his intention by one blast of the steam whistle.

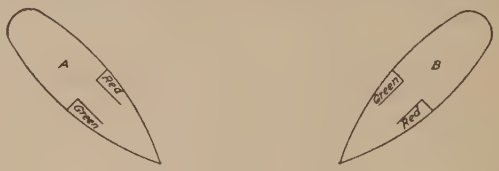


Fig. 42. Oblique Approach.

Fourth Situation. (Fig. 41.) This is a situation requiring great caution; the red light of *B* in view to *A*, and the green light of *A* in view to *B*, will inform both that they are approaching each other in an oblique direction. *A* should put his helm to port, and pass astern of *B*, while *B* should continue on his course, or port his helm if necessary to avoid collision, each having previously given one blast of the steam whistle, as required by the rules when passing to the right.

Fifth Situation. (Fig. 42.) This is a situation requiring great caution; the red light of *A* in view to *B*, and the green light of *B* in view to *A*, will inform both that they are approaching each other in an oblique direction. *B* should put his helm to port, and pass astern of *A*, while *A* should continue on his course, or port his helm if necessary to avoid a collision, each having previously given one blast of the steam whistle, as requried by the rules when passing to the right.

RULES FOR REVIVING PERSONS RESCUED FROM THE WATER

The following rules for reviving persons rescued from the water were issued by the Health Department of the City of New York, and being concise and complete, they are here reproduced for the information and guidance of the inexperienced.

First: Loosen the clothing; place the body face downward, with the forehead resting on one of the wrists, and the face turned to one side. Open the mouth, seize the tongue between the fingers—covered with a handkerchief or piece of cloth—and draw it forward between the teeth; clear the mouth and throat from mucus by passing the forefinger—covered with a handkerchief or piece of cloth—far back into the mouth, thus opening a free passage to the windpipe.

Second: Turn the body face upward, shoulders resting on a folded coat or pillow; keep tongue drawn forward. Raise the arms backward and upward to the sides of the head; this expands the chest and allows the air to enter the lungs; then slowly move them downward, bending them so that the elbows will come to the sides and the hands cross on the pit of the stomach, and press them gently but strongly against the sides and chest. This forces the air out of the lungs. Continue these two movements, which produce artificial breathing, very deliberately about ten or twelve times in a minute and without ceasing until the patient breathes naturally, or until you are satisfied that life is extinct.

Third: While this is being done, a little friction on the chest may be produced by rubbing gently with warm flannel, and the body may be stripped and then wrapped in dry blankets. After natural breathing begins, continue very gently for a few minutes the two movements which produce artificial breathing. After natural breathing is fully restored, give the patient a teaspoonful of brandy, hot sling, or tea, two or three times a minute, until the beating of the pulse can be felt at the wrist. Rub the arms and legs upward; and apply hot cloths to the body, legs, and arms, and hot water bottles to the feet.

Caution. 1. Do not be discouraged if animation does not return in a few minutes. The patient sometimes recovers after hours of labor.

2. Do not allow the tongue to fall back and close the windpipe while the arms are being worked.

3. Do not rub the legs and arms until natural breathing is restored.

4. Do not put any liquid in the mouth until natural breathing is fully restored.

5. Do not roll the body, or handle it roughly.

6. Do not allow the head to hang down.

REVIEW QUESTIONS

REVIEW QUESTIONS

ON THE SUBJECT OF

COMMERCIAL VEHICLES

PART I

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1. Give the general specifications of two makes of electric delivery vehicles.

2. Show in what fields the electric vehicle excels and why.

3. What particular advantage has the planetary transmission over the selective type on the commercial car?

4. Are there any marked changes in the specifications in passing from electric delivery wagons to trucks?

5. What are the standard requirements of taxicab service? Give a brief description of one type.

6. What limitations are placed on the load capacity of the gasoline truck? State why such limitations exist.

7. What limits the range of usefulness of the electric delivery wagon?

8. What is meant by *load efficiency?* How does this vary with the size of the vehicle and why?

9. Why did not the ordinary pleasure car adequately fill the needs of the taxicab?

10. Give general requirements for a commercial car and show in what particulars the pleasure car falls short.

11. Describe the *couple-gear* truck and show its advantages.

12. What is the friction drive and what are its advantages? Can this form be used on very large delivery wagons?

13. What limits, if any, are placed on the size of an electric truck?

14. Name the advantages and disadvantages in the use of Edison storage batteries in comparison with the regulation lead battery.

15. Show how the tire question is handled in the taxicab service.

16. Give advantages and disadvantages of the 2-cycle motor.

17. How can an internal combustion motor be made to give comparatively high efficiency on low speed?

18. Give the general specifications for a gasoline truck.

19. Give the general scheme of hydraulic transmission.

20. Give the usual form of springs on the gasoline delivery wagons and trucks.

REVIEW QUESTIONS

ON THE SUBJECT OF

COMMERCIAL VEHICLES

PART II

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1. What form did the early tractors take?

2. Give some of the methods by which the different manufacturers produce the amount of traction required to run a gang plow, for example.

3. What fuel is most common among tractors and why used?

4. Describe in detail the Sampson road train giving particular attention to the control mechanism.

5. What points are in favor of a road train in the transportation of a large amount of materials as compared with the individual trucks?

6. To what extent has the gasoline vehicle been applied to municipal fire service? Give some examples and show how this equipment has been developed.

7. What particular phases of the heavy vehicle problem are admirably solved by the gasoline-electric type?

8. Give mileage per gallon of fuel for a few of the important types of commercial vehicles.

9. Give figures to show the total cost per mile of a 5-ton and a 10-ton truck.

10. Can either gasoline or kerosene be economically used in an engine without change of the accessories? If not, why not?

11. Discuss the merits of alcohol as a fuel.

12. Give the general details of a producer-gas outfit for an automobile. What are its advantages? Disadvantages?

13. Compare the merits of rubber, steel, and wood as material for commercial tires.

14. Describe some of the methods of obtaining sufficient traction and rigidity with rubber tires on large trucks.

15. As an expert in commercial vehicle usage, you are requested to specify motor equipment to take the place of 100 one-horse delivery wagons, and five two-horse trucks. Fifty of these small delivery wagons receive their supply of packages direct from headquarters and cover routes averaging 26 miles daily travel. The five two-horse trucks are employed for transporting full loads to outlying distributing stations, the most distant of which is 18 miles from the store. The remaining fifty delivery wagons are attached to these outlying stations and serve routes averaging 32 miles daily travel. How many and what type of vehicles would you specify to displace the horse-drawn equipment?

16. You are called in an advisory capacity to discuss the question of motor equipment by a large wholesale house. The service required is of two distinct classes. First, loads averaging from two to four tons must be transported from the warehouse to steamship piers and railway depots—average distance $2\frac{1}{2}$ to 3 miles. Second, loads of four to five tons must be transported from the factory, eight miles distant, to the warehouse, and loads averaging three tons must be carried from the warehouse to jobbing customers situated at distances of from four to ten miles. State the nature of the equipment you would specify as the best adapted to meet every one of these conditions.

REVIEW QUESTIONS

ON THE SUBJECT OF

PRIVATE GARAGES AND REPAIRS

1. Give the arguments in favor of private garage as compared with public garage service.

2. Contrast city conditions and country or suburban conditions as regards the private garage problem.

3. Give a few of the standard type of garages, and name some of the advantages of each.

4. Compare, in a general way, the cost of a wood garage and one of concrete on metal lathe.

5. Give what arguments you can in favor of the square type of one-car garage; of the long type. Which would you prefer?

6. What are the particular advantages of a portable garage?

7. Name three very important elements in the design of a garage.

8. Why is the heating of a garage necessary, and how can it best be accomplished in the country?

9. Give the characteristics of a proper drain for a garage.

10. What is the necessity for an outside fuel tank, and of what should this equipment consist?

11. Describe an overhead washing apparatus. Should warm water be used for washing a car in winter, and if so how can this be provided?

12. Give some reasons why a turn table in a garage is a desirable feature. Give some of the main points in the design.

13. Why is it desirable that every car owner should be his own repair man as far as possible? Give a general idea of the equipment necessary for carrying on repairs.

14. What would be the ratio of the appropriation for the garage, and for the tools with which to equip it?

15. Name some of the handy homemade devices which help to make the work in a garage easier. Give the use of each.

16. Describe carefully the process of dismounting the engine for a general overhaul.

17. How are the pistons removed from the cylinders and returned to their places?

18. Give some of the characteristic troubles with bearings, and the method of their removal.

19. Describe the process of grinding a valve.

20. How do you cut out clutch leathers?

21. What are the main difficulties with the transmission, and how can these be eradicated?

22. Give some of the operations in the overhauling of a car which should not be attempted by a novice.

23. Describe briefly the construction of the ordinary outer tire casing.

24. What elements of attention and care will prolong the life of tires?

REVIEW QUESTIONS

ON THE SUBJECT OF

AUTOMOBILE DRIVING

1. What is the first thing to learn about driving an automobile?
2. What is the best and quickest way to do this?
3. Explain how this stops the car.
4. What is meant by the *emergency brakes?*
5. How do these act, where are they located, and how are they operated by the driver?
6. Describe the two kinds of *emergency brake levers*, and give the advantages of each.
7. What is meant by the *service brake* or *brakes?*
8. How do service brakes differ as to number and location?
9. What is a *slipping clutch?*
10. How is it fixed?
11. What is a *fierce* clutch and how is it altered?
12. Describe the cleaning and oiling of a chain.
13. What is the best form of *tubing* for gas bags and why?
14. Describe in detail the method of *lining up lamps?*
15. What are the two general principles of *passing a vehicle* ahead?
16. Mention the chief points in which care must be exercised in making a *blind turn.*
17. What rule must always be remembered in making turns?
18. Tell how you would get out of a blind court.
19. How often should engine valves be *ground in?*
20. Describe the method of doing this.
21. How are *carbon deposits* formed on cylinder walls, valves, and pistons?
22. Describe one method of *removing carbon.*

23. What is the effect of mixing graphite with lubricating oil, and what is the proper proportion?

24. How does a *carburetor* act?

25. Tell how moving the carbureter spray nozzle has bad effects, and describe the three cases in Fig. 43.

26. How may an engine be *choked?*

27. What is *misfiring,* and what are the principal causes?

28. What items in the carburetion system are most likely to cause misfiring?

29. How should a *fuel-logged cork float* be fixed? A *punctured metal float?*

30. What measuring instruments are most useful in detecting electrical faults?

31. What is the cause of the trouble shown by a uniform or gradual drop of the voltmeter reading with a regular reading of the ammeter?

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